

Vol. 1 of 3

Sandia National Laboratories/New Mexico

**PROPOSALS FOR NO FURTHER ACTION
ENVIRONMENTAL RESTORATION PROJECT
SWMUs 16, 228A, 65A, 65B, 65C, AND 94E**

September 1999

Environmental
Restoration
Project



United States Department of Energy
Albuquerque Operations Office

EXECUTIVE SUMMARY

Sandia National Laboratories/New Mexico is proposing a risk-based no further action (NFA) decision for Solid Waste Management Units (SWMU) 16, 228A, 65A, 65B, 65C, and 94E. Review and analysis of all relevant data for these SWMUs indicate that concentrations of constituents of concern (COC) at these sites do not pose an unacceptable risk to human health or the environment. Thus, these SWMUs are proposed for an NFA decision based upon confirmatory sampling data demonstrating that COCs that could have been released from the SWMUs into the environment pose an acceptable level of risk under current and projected future land use, as set forth by Criterion 5, which states, "The SWMU/AOC [area of concern] has been characterized or remediated in accordance with current applicable state or federal regulations, and the available data indicate that contaminants pose an acceptable level of risk under current and projected future land use" (NMED March 1998). This executive summary briefly describes each of the above-listed SWMUs.

- SWMU 16 (the Open Dumps in Arroyo del Coyote in Operable Unit [OU] 1309), an inactive site, was used as an uncontrolled trash dump and gravel quarry from the late 1950s to the late 1980s. A radiological voluntary corrective measure (VCM) was conducted at SWMU 16 in 1995 and 1996 (Phase I) and 1997 and 1998 (Phase II). Confirmatory sampling analyses revealed residual metals and radionuclides. The site assessment concludes that SWMU 16 does not have the potential to affect human health under a recreational land-use scenario. After considering the uncertainties associated with the available data and modeling assumptions, it was determined that ecological risks associated with SWMU 16 were very low.
- SWMU 228A (the Centrifuge Dump Site in OU 1309), inactive since the 1950's, was used for the disposal of weapons debris and construction debris on the northern rim of Tijeras Arroyo. A radiological VCM was conducted at the site in 1998 and 1999. Subsequent sampling analyses revealed residual metals, volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), and radionuclides at SWMU 228A. The site assessment concludes that SWMU 228A does not have the potential to affect human health under a recreational land-use scenario. After considering the uncertainties associated with the available data and modeling assumptions, it was determined that ecological risks associated with SWMU 228A were low.
- SWMU 65A (the Small Debris Mound in OU 1333), an inactive subunit of SWMU 65, was a small concrete bunker (covered with soil) that could have been used for an explosives propagation test at the Lurance Canyon Explosives Test Site (LCETS). A radiological VCM was conducted to excavate and demolish the bunker in March 1999. Subsequent sampling analyses collected under the bunker floor after its removal revealed residual metals and radionuclides slightly above background concentration limits at SWMU 65A. The site assessment concludes that SWMU 65A does not have the potential to affect human health under a recreational land-use scenario. After considering the uncertainties associated with the available data and modeling assumptions, it was determined that ecological risks associated with SWMU 65A were very low.

- SWMU 65B (the Primary Detonation Area in OU 1333), an inactive subunit of SWMU 65, was the detonation area for general explosives tests, miscellaneous burn tests, slow-heat tests, and the Torch-Activated Burn System Test Location A at the LCETS. A radiological VCM was conducted at the site in 1995 and 1996. Point sources and small area sources were removed in 1995. Larger area sources were remediated in 1996. Subsequent sampling analyses revealed residual metals and radionuclides at SWMU 65B. The site assessment concludes that SWMU 65B does not have the potential to affect human health under a recreational land-use scenario. After considering the uncertainties associated with the available data and modeling assumptions, it was determined that ecological risks associated with SWMU 65B were very low.
- SWMU 65C (the Secondary Detonation Area in OU 1333), an inactive subunit of SWMU 65, was used to conduct general explosives tests and miscellaneous burn pit tests at the LCETS. A radiological VCM was conducted at the site in 1995 and 1996. Point sources and small area sources were removed in 1995. Larger area sources were remediated in 1996. Subsequent sampling analyses revealed residual metals, VOCs, SVOCs, and radionuclides at SWMU 65C. The site assessment concludes that SWMU 65C does not have the potential to affect human health under a recreational land-use scenario. After considering the uncertainties associated with the available data and modeling assumptions, it was determined that ecological risks associated with SWMU 65C were very low.
- SWMU 94E (the Small Surface Impoundment in OU 1333), an inactive subunit of SWMU 94, was an impoundment used for several fuel-fire burn tests which may have received wastewater from some portable pan burn tests at the Lurance Canyon Burn Test Site. A radiological VCM was conducted in 1996. Confirmatory sampling analyses performed in 1996 and 1998 revealed residual metals and radionuclides at the site. The site assessment concludes that SWMU 94E does not have the potential to affect human health under a recreational land-use scenario. After considering the uncertainties associated with the available data and modeling assumptions, it was determined that ecological risks associated with SWMU 94E were very low.

REFERENCES

New Mexico Environment Department (NMED), March 1998. "RPMP Document Requirement Guide," Hazardous and Radioactive Materials Bureau, RCRA Permits Management Program, New Mexico Environment Department, Santa Fe, New Mexico.

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ACRONYMS AND ABBREVIATIONS

amsl	above mean sea level
AOC	area of concern
bgs	below ground surface
COA	City of Albuquerque
CEARP	Comprehensive Environmental Assessment and Response Program
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cm ²	square centimeter(s)
COC	constituent of concern
CON-CON	Conical Container
cpm	counts per minute
DOE	U.S. Department of Energy
dpm	disintegration(s) per minute
DU	depleted uranium
ECF	Explosive Components Facility
EM	electromagnetic
EPA	U.S. Environmental Protection Agency
EP-TOX	extraction procedure toxicity
ER	environmental restoration
FIP	Field Implementation Plan
g	gram(s)
GEL	General Engineering Laboratory
GM	Geiger-Mueller
HE	high explosive(s)
HI	hazard index
HMX	1,3,5,7-tetranitro-1,3,5,7-tetrazacyclooctane
HQ	hazard quotient
hr	hour(s)
HRMB	Hazardous and Radioactive Materials Bureau
HRS	hazard ranking system
HSWA	Hazardous and Solid Waste Amendments
ID	identification
JP-4	jet fuel composition 4
KAFB	Kirtland Air Force Base
kg	kilogram(s)
L	liter(s)
LAARC	Light Airtransport Accident Resistant Container
LCBS	Lurance Canyon Burn Site
LCETS	Lurance Canyon Explosives Test Site
MCL	maximum contaminant levels
MDA	minimum detectable activity
MDL	method detection limit
µg	microgram(s)
mg	milligram(s)
mrem	millirem(s)
MS	matrix spike
NFA	no further action
NMED	New Mexico Environment Department
NTS	Nevada Test Site
OB	Oversight Bureau
OU	Operable Unit

ACRONYMS AND ABBREVIATIONS (Concluded)

PCB	polychlorinated biphenyls
PCE	perchloroethylene
pCi	picocurie(s)
PID	photoionization detector
PPE	personal protective equipment
ppm	part(s) per million
PQL	practical quantitation limit(s)
PRG	preliminary remediation goal
QA	quality assurance
QC	quality control
RCRA	Resource Conservation and Recovery Act
RCT	radiological control technician
RDX	1,3,5-trinitrobenzene
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
RMMA	Radiological Materials Management Area
RMWMF	Radioactive and Mixed Waste Management Facility
RPD	relative percent difference
RPSD	Radiation Protection Sample Diagnostics
RSI	Request for Supplemental Information
SAP	sampling and analysis plan
SGS	Segmented Gate System
SMERF	Smoke Emissions Reduction Facility
SNL/NM	Sandia National Laboratories/New Mexico
SVOC	semivolatile organic compound
SVS	soil vapor survey
SWISH	Small Wind-Shielded
SWMU	Solid Waste Management Unit
TA	Technical Area
TABS	Torch-Activated Burn System
TAL	target analyte list
TCA	1,1,2-trichloroethane
TCE	trichloroethylene
TCLP	toxicity characteristic leaching procedure
TEDE	total effective dose equivalent
tics	total ion counts
TJAOU	Tijeras Arroyo Operable Unit
TNT	trinitrotoluene
TPH	total petroleum hydrocarbons
UXO	unexploded ordnance
VCA	voluntary corrective action
VCM	voluntary corrective measure
VOC	volatile organic compound
yr	year

1.0 INTRODUCTION

Sandia National Laboratories/New Mexico (SNL/NM) is proposing No Further Action (NFA) proposals for six environmental Restoration (ER) Solid Waste Management Units (SWMUs). The following SWMUs are listed in the Hazardous and Solid Waste Amendments Module IV of the SNL/NM Resource Conservation and Recovery Act Hazardous Waste Management Facility Permit (NM5890110518) (EPA August 1993). Proposals for each SWMU are located in this document as follows:

Operable Unit 1309

- SWMU 16, Open Dumps, Arroyo del Coyote (Section 2.0)
- SWMU 228A, Centrifuge Dump Site (Section 3.0)

Operable Unit 1333

- SWMU 65A, Small Debris Mound, Lurance Canyon Explosives Test Site (Section 4.0)
- SWMU 65B, Primary Detonation Area, Lurance Canyon Explosives Test Site (Section 5.0)
- SWMU 65C, Secondary Detonation Area, Lurance Canyon Explosives Test Site (Section 6.0)
- SWMU 94E, Small Surface Impoundment, Lurance Canyon Burn Test Site (Section 7.0)

These proposals each provide a site description, history, summary of investigatory activities, and the rationale for the NFA decision, as determined from assessments predicting acceptable levels of risk under current and projected future land use.

REFERENCES

U.S. Environmental Protection Agency (EPA), August 1993, "Module IV of RCRA Permit No. NM5890110518-1," EPA Region VI, issued to Sandia National Laboratories, Albuquerque, New Mexico.

3.0 ENVIRONMENTAL RESTORATION SWMU 228A, CENTRIFUGE DUMP SITE

3.1 Summary

Sandia National Laboratories/New Mexico (SNL/NM) is proposing a risk-based No Further Action (NFA) decision for Solid Waste Management Unit (SWMU) 228A, Operable Unit 1309. SWMU 228A, the Centrifuge Dump Site, is located east of SNL/NM Technical Area (TA) II on the northern rim of the Tijeras Arroyo. Environmental concern for SWMU 228A is primarily based upon depleted uranium (DU) fragments that were present in a steep gully and an adjoining alluvial fan. The DU fragments had been dumped along the arroyo rim with other weapon debris and some construction debris. The DU fragments and debris were removed from SWMU 228A during 1998 and 1999 voluntary corrective measure (VCM) activities.

Review and analysis of all relevant data for SWMU 228A indicate that concentrations of contaminants of concern (COC) are less than applicable risk-assessment action levels. Thus, SWMU 228A is being proposed for an NFA decision based upon confirmatory sampling data demonstrating that COCs released from this SWMU into the environment pose an acceptable level of risk under current and projected future land use, as set forth by NFA Criterion 5, which states, "the SWMU/AOC [area of concern] has been characterized or remediated in accordance with current applicable state or federal regulations, and the available data indicated that contaminants pose an acceptable level of risk under current and projected future land use" (NMED March 1998).

3.2 Description and Operational History

This section describes SWMU 228A and discusses its operational history.

3.2.1 SWMU Description

SWMU 228A, the Centrifuge Dump Site, covers 1.6 acres and is located about 500 feet east of the historic TA-II boundary on the northern rim of the Tijeras Arroyo (Figure 3.2.1-1). The recently constructed Explosive Components Facility (ECF) is located about 500 feet north of the SWMU. SWMU 228A is situated on land that is owned by Kirtland Air Force Base (KAFB) and permitted to the U.S. Department of Energy (DOE). The site is situated on the steeply sloping rim of the Tijeras Arroyo and the nearly flat floodplain below (Figure 3.2.1-2). Ground elevations at SWMU 228A range from 5,405 feet at the northern site boundary to about 5,360 feet at the southern site boundary on the Tijeras Arroyo floodplain. The vicinity is unpaved and no storm sewers are used to direct surface water. The extreme southern end of SWMU 228A is located within the 100-year Tijeras Arroyo floodplain (Figure 3.2.1-3). However, the site is located approximately 800 feet from the active channel, which only flows several times each year at Powerline Road. The Tijeras Arroyo is the most significant surface-water drainage feature on KAFB. The arroyo originates in the Tijeras Canyon, which is bounded by the Sandia Mountains to the north and the Manzano Mountains to the south. The arroyo trends southwest along the southern edge of the site and eventually drains into the Rio Grande, approximately 9 miles west of SWMU 228A.

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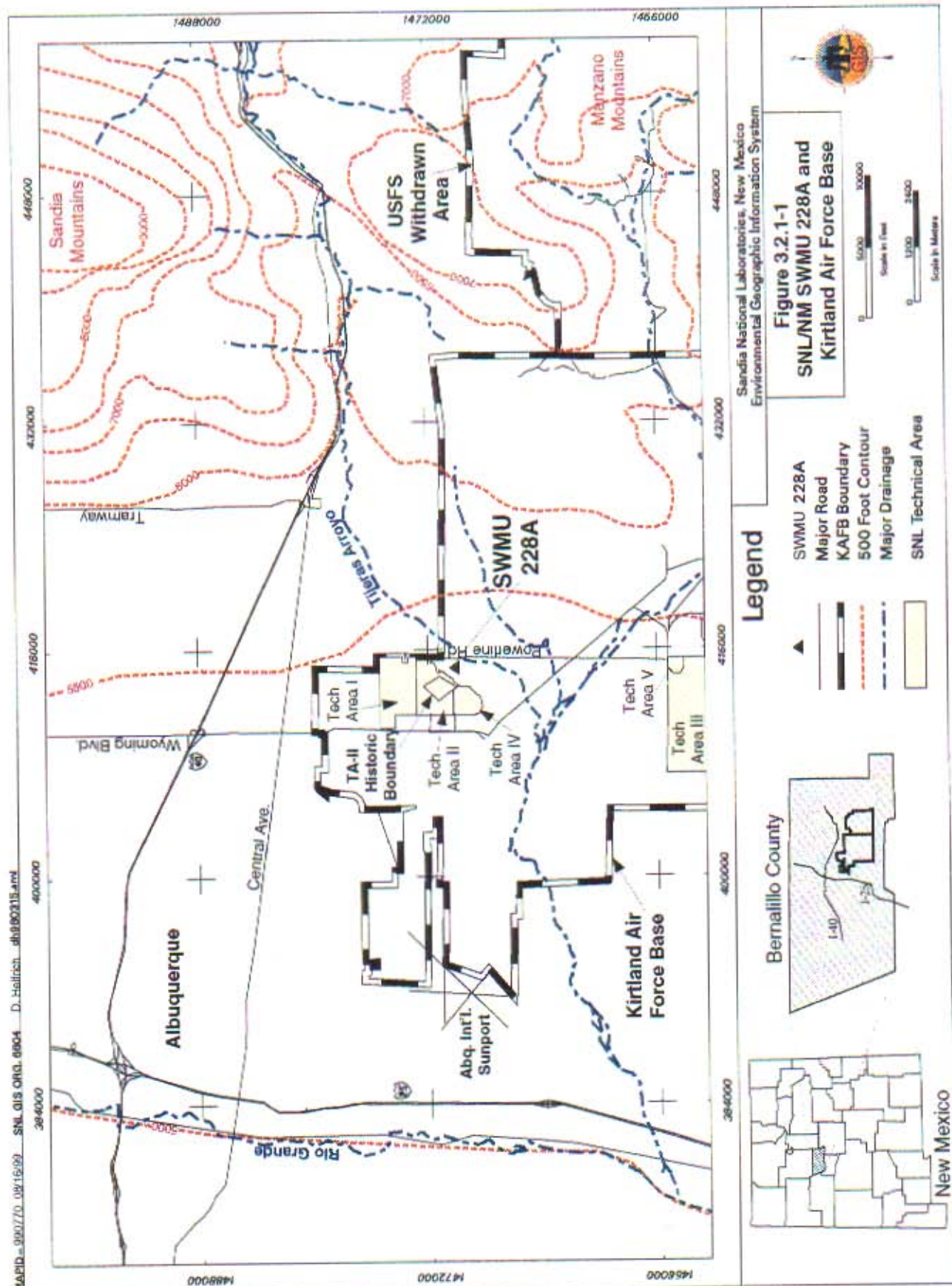
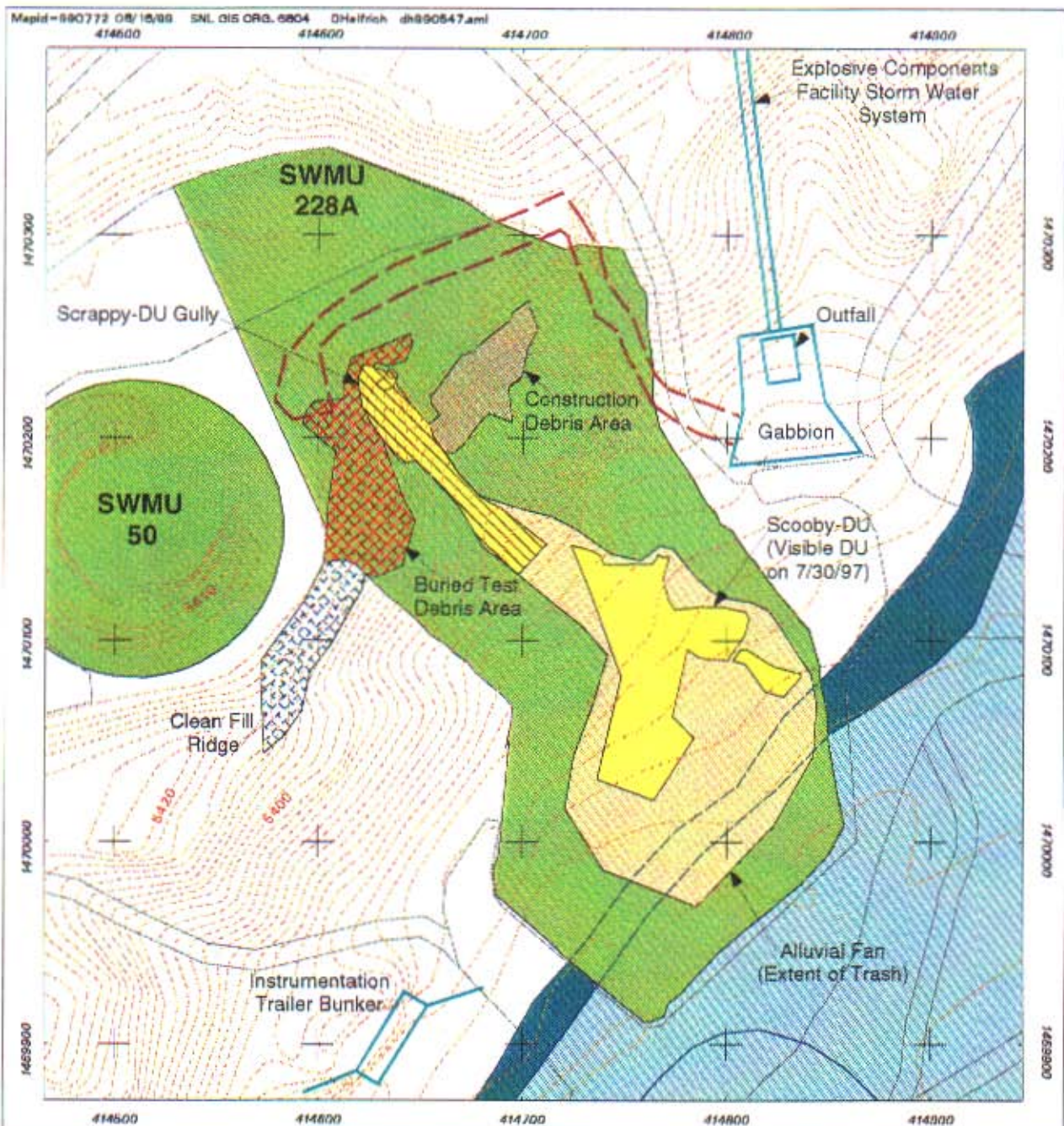




Figure 3.2.1-2

Aerial photograph of SWMU 228A, Sandia National Laboratories/New Mexico (February 1999) before final grading and revegetation work. View to the northwest with TA-II in left background. SWMU 50 and

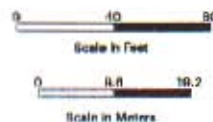
Scrappy-DU gully are in the center of photograph.



Legend

	2 Foot Contour		Clean Fill
	Unpaved Road		Buried Test Debris
	Diversion Ditch		Construction Debris
	Bunker / Outfall		Scooby-DU
	SWMU 228A & 50		Scrappy-DU Gully
	100 Yr. Flood Plain		Alluvial Fan
	500 Yr. Flood Plain		

**Figure 3.2.1-3
VCM Remediation Areas
at SWMU 228A**



Sandia National Laboratories, New Mexico
Environmental Geographic Information System

The annual precipitation for the area, as measured at the Albuquerque International Sunport, is 8.1 inches (NOAA 1990). No springs or perennial surface-water bodies are located within 2 miles of the site. During most rainfall events, rainfall quickly infiltrates the soil at SWMU 228A. However, virtually all of the moisture undergoes evapotranspiration. Evapotranspiration estimates for the KAFB area range from 95 to 99 percent of the annual rainfall (Thompson and Smith 1985, SNL/NM February 1998a).

Groundwater monitoring for the area surrounding SWMU 228A is conducted as part of the Sandia North groundwater investigation (SNL/NM July 1999). Four monitoring wells (TA2-W-24, TA2-W-25, TA2-W-26, and TA2-W-27) are located within 400 feet of SWMU 228A. Two water-bearing zones, the shallow groundwater system and the regional aquifer, underlie SWMU 228A. The shallow groundwater system is not used for water supply. The depth to the shallow groundwater system is approximately 280 feet below ground surface (bgs) near the southern end of SWMU 228A. The depth to the regional aquifer is approximately 450 feet bgs. Both the City of Albuquerque and KAFB use the regional-aquifer for water supply. The nearest water-supply well, KAFB-11, is located approximately 0.7 mile east of SWMU 228A. The nearest downgradient water-supply well is KAFB-1, which is located approximately 1.4 miles northwest of the site.

Grasslands are the dominant plant community surrounding SWMU 228A and include species such as blue/black grama and western wheatgrass (SNL/NM December 1997). The site is principally vegetated by ruderal species such as Russian thistle (tumbleweed).

Soil at the site has been identified as the Bluepoint-Kokan Association (SNL/NM December 1997). For purposes of defining the background levels of metals and radionuclides in soil, this soil has been included as part of the North Supergroup (IT Corporation March 1996). The Bluepoint-Kokan Association consists of the Bluepoint loamy fine sand, which is developed on slopes of 5 to 15 percent, and the Kokan gravelly sand on slopes of 15 to 40 percent (SNL/NM December 1997). These soils are slightly calcareous and mildly to moderately alkaline. Runoff potential for these soils ranges from slow to very rapid, and the hazard of water erosion is slight to severe. Water permeability is moderate to very rapid. The surficial deposits are underlain by the upper unit of the Santa Fe Group. The upper Santa Fe Group consists of coarse- to fine-grained fluvial deposits from the ancestral Rio Grande that intertongues with coarse-grained alluvial fan/piedmont veneer facies, which extend westward from the Sandia and Manzanita Mountains. The upper Santa Fe unit is approximately 1,200 feet thick in the vicinity of the site.

Environmental concern about SWMU 228A was based upon weapons debris and construction debris that was dumped at the site in the 1950s. The weapons debris, including DU fragments, came from the adjacent centrifuge (SWMU 50). Following some centrifuge tests in the mid-1950s, weapons debris was dumped in a gully located about 80 feet east of the centrifuge. This gully eventually became part of SWMU 228A. The weapons debris was dumped next to construction debris from the demolition of KAFB barracks that had been previously dumped in the early 1950s. Except for a limited amount of cleanup in 1994, the weapons and construction debris remained near the upper end of the gully until 1997.

Unfortunately, heavy rainfall on July 28, 1997, washed some of the weapons and construction debris farther down the gully and onto the Tijeras Arroyo floodplain. On the following day, the ER Project discovered the DU fragments at SWMU 228A and the lateral extent of the new alluvial fan was mapped on the basis of visible DU fragments, trash, and sand deposition. The alluvial-fan deposit became known as Scooby-DU because of its distinctive outline

(Figure 3.2.1-3). Scooby-DU covered approximately 0.1 acre with an estimated maximum thickness of about 3 feet. During the planning stages of the VCM, the gully earned the nickname Scrappy-DU gully (Figure 3.2.1-4). At its northern end, the Scrappy-DU gully was about 10 feet wide and had steeply sloping walls about 8 feet high. The gully flared out southward on the Scooby-DU alluvial fan deposit.

Following the discovery of DU fragments in July 1997, the southern boundary for SWMU 228A was moved about 220 feet southward to encompass the alluvial-fan deposit (Scooby-DU). Just prior to the start of the VCM cleanup operation in June 1998, the northern boundary was moved about 100 feet northward so that a waste-staging area could be prepared. At present, SWMU 228A covers 1.6 acres.

3.2.2 Operational History

Historical records and technical memoranda have provided a significant level of process knowledge for the centrifuge testing activities. Weapons operations at the centrifuge are well documented in a series of classified memoranda written by SNL/NM engineers and scientists (Green January 1998). The centrifuge was constructed in 1952 within an abandoned meander-loop above the Tijeras Arroyo floodplain (Furman 1990). This rocket-powered centrifuge was not covered by a building or other structure. The centrifuge was used from 1952 through 1956 to test arming, fuzing, and firing components at high rates of centrifugal acceleration (Green January 1998). For test containment purposes, native soil was used to construct a 7-foot-high berm around the 80-foot-diameter concrete slab and to build up a nearby section of the arroyo rim. The centrifuge pivot was located in the center of the concrete slab. The centrifuge boom was 50 feet in length and held an experimental apparatus test jig on one end and rocket motors on the other end to provide rapid acceleration. During some tests, the test jigs contained DU and high explosive (HE) components. The most commonly used HE was probably 1,3,5-trinitrobenzene (RDX), also known as cyclonite. However, none of the HE spheres or detonators were apparently fired (expended) during the tests. Some test jigs used concrete spheres to simulate the HE spheres.

As mentioned earlier, the debris at SWMU 228A consisted of weapons debris from the SWMU 50 centrifuge and construction debris from the demolition of KAFB barracks. The weapons debris consisted mostly of DU fragments, rubber pads, aluminum pieces, concrete spheres, and small electrical components. Because SWMU 228A received weapons debris from centrifuge operations, the potential existed for unexploded ordnance (UXO)/HE material such as rocket motors or explosive charges also to be buried in or near the Scrappy-DU gully. However, no explosive materials were found during the VCM remediation. The construction debris consisted mostly of scrap metal and concrete rubble. The excavated debris is discussed in more detail in Section 3.4.5.2.2.

3.3 Land Use

This section discusses the current and projected future land use for SWMU 228A.



Figure 3.2.1-4

July 1997 photograph of the Scrappy-DU gully showing weapon and construction debris at SWMU 228A.
The original dump site of the DU fragments was on left side of the gully near the skyline.

3.3.1 Current Land Use

SWMU 228A is located on federally owned land permitted to the DOE by the U.S. Air Force within the boundaries of KAFB (Figure 3.2.1-1). The current land use is industrial. After the cessation of centrifuge tests and debris burial in 1956, no significant land uses have occurred. Except for occasional Environmental Restoration (ER) Project activities in the 1990s, the vicinity of SWMU 228A has served as a buffer zone for TA-II and the ECF. The site is not fenced and, because of its remote location, is infrequently visited by non-ER Project personnel.

3.3.2 Future/Proposed Land Use

The projected land use for SWMU 228A is industrial (DOE et al. September 1995, SNL/NM November 1997). According to the SNL/NM 10-year Master Plan, no roads or buildings of any sort are planned for the vicinity of SWMU 228A (SNL/NM May 1999).

3.4 Investigatory Activities

The four investigations for SWMU 228A include the work that has been conducted at both SWMU 50 and SWMU 228A.

3.4.1 Summary

The vicinity of SWMU 228A was initially investigated under the DOE Comprehensive Environmental Assessment and Response Program (CEARP) in the mid-1980s in conformance with the Comprehensive Environmental Response, Compensation and Liability Act (Investigation #1). Investigation #2 included a cultural-resources survey, CEARP Phase 2 soil sampling at SWMU 50, and ER Project soil sampling. From 1994 through early 1998, various investigations such as surface radiological surveys and geophysical surveys were conducted at SWMU 228A (Investigation #3). From mid-1998 through early 1999, a thorough VCM with confirmatory sampling was conducted at SWMU 228A (Investigation #4).

3.4.2 Investigation #1—CEARP

3.4.2.1 Nonsampling Data Collection

SWMU 228A was not identified in the 1987 CEARP; however, the adjacent centrifuge and instrumentation bunker were identified as SWMU 50, the Centrifuge Test Site (DOE September 1987). The CEARP briefly discussed the testing activities that had occurred at the centrifuge. However, the CEARP did not identify the weapons debris that was buried in the gully directly east of the centrifuge. The presence of large concrete slabs and other construction debris had apparently hidden the weapons debris.

3.4.2.2 *Sampling Data Collection*

No sampling activities were conducted at SWMU 228A as part of the CEARP effort.

3.4.2.3 *Data Gaps*

SWMU 228A was not identified in the CEARP; therefore, no Hazard Ranking System (HRS) and Modified HRS migration mode scores were calculated. Furthermore, SWMU 228A was not investigated as part of the Resource Conservation and Recovery Act (RCRA) facility assessment (EPA April 1987).

3.4.2.4 *Results and Conclusions*

No CEARP findings were prepared for SWMU 228A.

3.4.3 Investigation #2—CEARP Phase 2/SWMU 50 NFA

3.4.3.1 *Nonsampling Data Collection*

A cultural-resources survey was conducted in 1990 for SNL/NM Facilities Engineering. The survey area extended along the northern rim of Tijeras Arroyo from TA-IV to Powerline Road. No cultural resources such as archaeological artifacts were identified in the vicinity of the centrifuge or SWMU 228A (Chambers Group, Inc., March 1990).

3.4.3.2 *Sampling Data Collection*

Even though no samples were collected at SWMU 228A during Investigation #2, soil samples from SWMU 50 provided more insight for evaluating the potential COCs at SWMU 228A. As part of the 1989 CEARP Phase 2 Reconnaissance Data Report (DOE January 1989), surface soil samples were collected at 14 locations surrounding the centrifuge. A field inspection in November 1997 found wooden stakes at 11 of the 14 locations (Figure 3.4.3-1). The samples were collected from depths of less than 0.5 foot bgs. These SNA50-series samples were analyzed by a Roy F. Weston, Inc., laboratory for 11 suites of analytes: metals (target analyte list [TAL]; extraction procedure toxicity [EP-TOX]; and toxicity characteristic leachate procedure [TCLP]); pesticides (EP-TOX and TCLP); polychlorinated biphenyls (PCB); herbicides (EP-TOX and TCLP); semivolatile organic compounds (SVOC); 2,4,6-trinitrotoluene (TNT); and isotopic/total uranium. This lengthy and conservative list of analytes reflected the lack of process knowledge available during the CEARP effort, although DOE (January 1989) does state that "rocket propellant is the only known contaminant at this site" (page 2). The analytical results did not indicate any soil contamination in the vicinity of the centrifuge (Annex 3-A). Averaged values for the TAL metals and uranium are within the range of recently established New Mexico Environment Department (NMED) Hazardous and Radioactive Materials Bureau (HRMB) background values for the Sandia North Supergroup soil. The other metals results were nondetect and/or were below the RCRA TCLP and EP-TOX standards. No pesticides, PCBs, herbicides, SVOCs, or TNT were detected.

In 1994 soil samples were collected from four locations at the open side of the centrifuge berm. The soil-sampling results were used for the June 1995 NFA proposal for SWMU 50 (SNL/NM

June 1995) and fully documented in the 1996 Notice of Deficiency response (SNL/NM October 1996). The eight soil samples (50-01-A, 50-01-B, 50-02-A, 50-02-B, 50-03-A, 50-03-B, 50-04-A, and 50-04-B) were analyzed for HE compounds, radionuclides, and RCRA metals. The *A* designator in the sample number denotes a sampling depth of 0 to 0.5 foot bgs, whereas the *B* designator denotes a sampling depth of 0.5 to 3 feet bgs. The ENCOTEC, Inc., laboratory analyzed the samples for HE compounds and RCRA metals using EPA Methods 8330 and 6010/7471 (EPA November 1986), respectively. The isotopic uranium, plutonium, and tritium analyses were conducted by Quanterra, Inc., using methods HASL-300 (EML February 1997) and EERF-H01. Gamma spectroscopy analyses were conducted by the SNL/NM Radiation Protection Sample Diagnostics (RPSD) laboratory.

No HE compounds were detected in any of the soil samples. Four (arsenic, barium, cadmium, and lead) of the eight RCRA metals slightly exceeded the HRMB-approved background value (Table 3.4.3-1). The uranium activities did not exceed the HRMB-approved background values. Plutonium-238 and plutonium-239/240 were not detected in any of the samples above the minimum detectable activities (MDA) of 0.008 and 0.004 picocurie (pCi) per gram (/g), respectively. The maximum tritium activity in soil was 0.038 pCi/g, which is equivalent to 380 pCi/liter (L) in soil with a soil moisture of 10 percent. None of the soil samples contained tritium in excess of the HRMB background value of 420 pCi/L (Tharp 1999). A complete set of analytical results for these samples was submitted to the NMED (SNL/NM October 1996). The NFA proposal for SWMU 50 is expected to be approved by the NMED in 1999 (Miller June 1999).

Table 3.4.3-1
Comparison of Maximum Metal Concentrations for SWMU 50 NFA Proposal Soil Samples to Background Values

RCRA Metal	Maximum Soil Concentrations at SWMU 50 (mg/kg, ppm)	Maximum Background Value ^a for North Supergroup Surface Soil (mg/kg, ppm)
Arsenic (As)	8	4.4
Barium (Ba)	220	200
Cadmium (Cd)	1.6	0.9
Chromium (Cr)-total	5	12.8
Lead (Pb)	25	11.2
Mercury (Hg)	<0.04	<0.1
Selenium (Se)	<0.025	<1
Silver (Ag)	<0.50	<1

Sample numbers: 50-01-A, 50-01-B, 50-02-A, 50-02-B, 50-03-A, 50-03-B, 50-04-A, 50-04-B.

^aDinwiddie 1997.

HRMB = Hazardous and Radioactive Materials Bureau.

mg/kg = Milligram(s) per kilogram.

NFA = No further action.

ppm = Parts per million.

RCRA = Resource Conservation and Recovery Act.

SNL/NM = Sandia National Laboratories/New Mexico.

SWMU = Solid Waste Management Unit.

3.4.3.3 Data Gaps

Investigation #2 did not characterize the debris and soil contamination at SWMU 228A.

3.4.3.4 *Results and Conclusions*

Investigation #2 provided a starting basis for future work at SWMU 228A. The investigation was useful for evaluating potential COCs.

3.4.4 Investigation #3—SNL/NM ER Project Preliminary Investigation

3.4.4.1 *Nonsampling Data Collection*

The non-sampling data-collection activities included a background review, a UXO/HE survey, radiological surveys, a cultural-resources survey, sensitive-species surveys, aerial photography interpretation, a soil-vapor survey, and geophysical surveys.

3.4.4.1.1 *Background Review*

Because of the over 40-year gap between the cessation of centrifuge tests and the preliminary investigations by the ER Project, personnel interviews were not conducted. Instead, a comprehensive records search was conducted for SWMU 228A in 1998. This archival research involved the records search and subsequent review of classified technical memoranda at the SNL/NM Technical Library Vault. A significant amount of process knowledge was identified. Over 100 memoranda were found that discuss centrifuge operations for the entire testing period of 1952 through 1956. Relevant memoranda were subsequently declassified (Green January 1998) and used as the basis for the weapons testing information discussed in Section 3.2.2. Furman (1990) also briefly discussed centrifuge operations.

3.4.4.1.2 *UXO/HE Survey*

Visual surveys for UXO/HE material were conducted at SWMUs 50 and 228A by KAFB Explosive Ordnance Disposal and ER staff in 1994. No UXO/HE was observed at either site. ER staff also conducted visual surveys following the July 1997 erosion and the VCM cleanup operation. Again, no UXO/HE material was observed.

3.4.4.1.3 *SNL/NM ER Project Surface Radiological Surveys*

As part of the 1994 Surface Radiological VCM that was conducted at many of the SNL/NM outdoor testing areas, RUST Geotech Inc. conducted a gamma radiation survey of the ground surface in the vicinity of SWMU 228A (SNL/NM September 1997). The survey included the area that is now the northern one-third of SWMU 228A. The southern two-thirds of the site had not yet been included as part of the site when the RUST Geotech Inc. survey was conducted. Two radioactive anomalies (228E1 and 228E2) were identified at the north end of the gully at SWMU 228A (Figure 3.4.3-1). The two anomalies were partially excavated with a backhoe and 13 drums of waste were generated by RUST Geotech Inc. Twelve drums were filled with DU-contaminated soil; the other drum was filled with about 200 pounds of DU fragments, including a 40-pound fragment informally called the "bowling ball" (Mitchell April 1999). The remainder of

the two anomalies was left for future remediation because of the steep gully walls and large concrete slabs that were beyond the capabilities of the backhoe.

During late 1997 and early 1998, a more elaborate surface radiological survey was conducted across most of SWMU 228A, excluding the Scrappy-DU gully (MDM/Lamb, Inc., February 1998). A DU-specific methodology was developed for the site using a Ludlum 44-10 sodium iodide scintillation detector coupled to a Ludlum 2350-1 ratemeter. A series of empirical tests was conducted using the typical weathered DU fragments found on site. The sensitivity of the sodium iodide detector was evaluated both vertically and laterally, and an optimal scanning height and sweeping pattern was determined for the site. Survey data from a nearby undisturbed plot were used to determine that background gamma radiation for the site was approximately 12,500 counts per minute (cpm). Gamma spectroscopy results for 14 soil samples collected from Scooby-DU and the background plot were used to determine a cpm to pCi/g conversion factor that was subsequently used for evaluating the extent of DU contamination. The radiological survey identified about 60 DU anomalies across Scooby-DU (Figure 3.4.4-1).

3.4.4.1.4 Project Cultural-Resources Survey

A 100-percent coverage, walk-over survey was conducted by an archaeologist in 1994. No cultural resources were found in the vicinity of SWMU 228A (Hoagland September 1994).

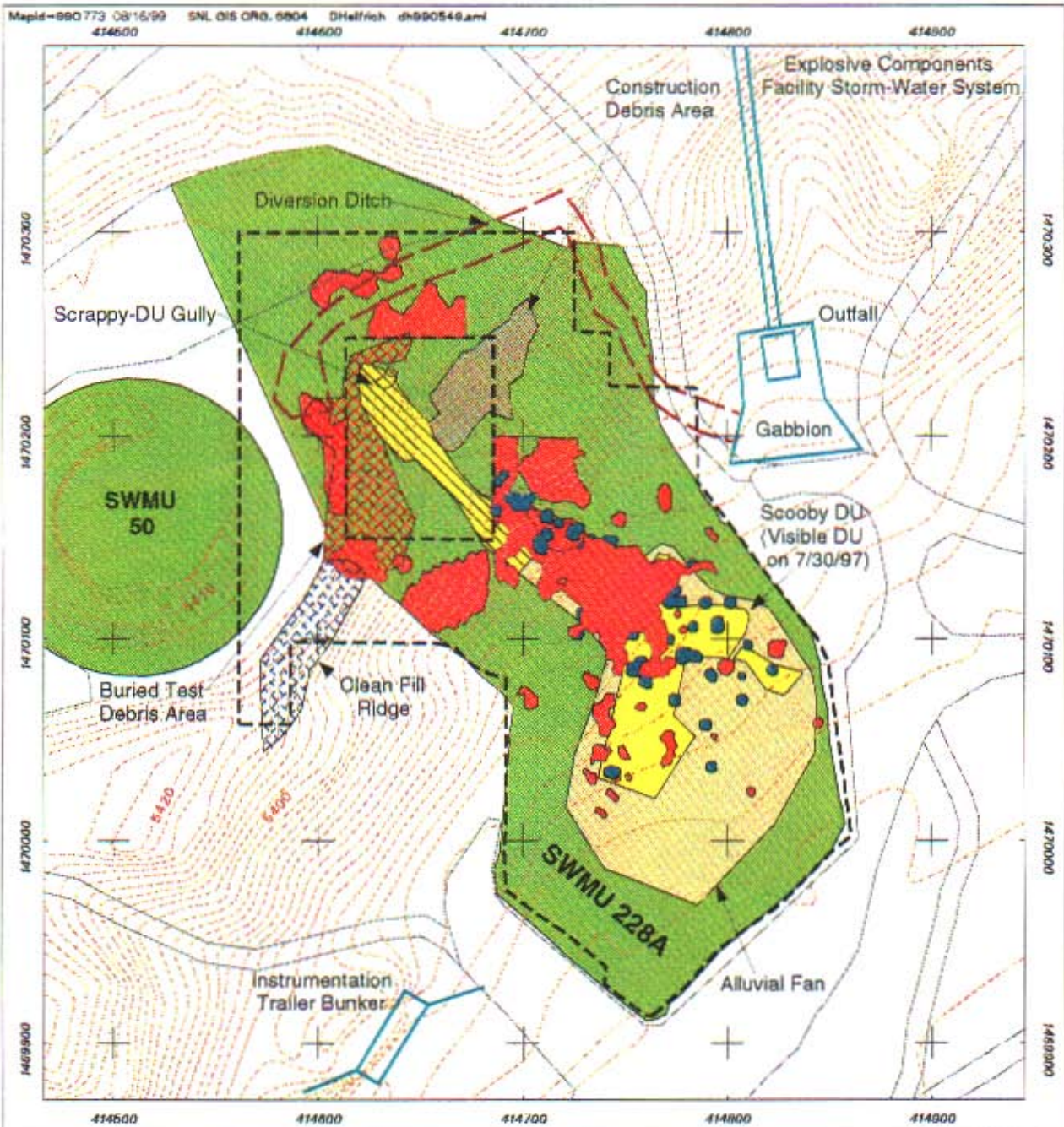
3.4.4.1.5 Sensitive-Species Surveys

In 1995 two biological surveys were conducted in the vicinity of SWMU 228A (IT Corporation February 1995). The area around SWMU 228A was originally desert grassland habitat but has been highly disturbed by its past use as a centrifuge test site and a dump (IT Corporation February 1995). Furthermore, TA-II and the ECF are located nearby. Grasslands species, primarily blue/black grama and western wheatgrass, surround SWMU 228A. However, the site is principally vegetated by ruderal species such as Russian thistle (tumbleweed). The indigenous wildlife includes reptiles, birds, and small mammals. However, wildlife use is limited by the degree of disturbance and its proximity to operational facilities. No riparian or wetland habitats are present within four miles of SWMU 228A. No federally listed endangered or threatened species (plants or animals) or state-listed endangered wildlife species (Group 1 or Group 2) are known to occur within the vicinity. No natural water bodies or wetlands are present, and all surface-water flows are intermittent, occurring during periods of precipitation.

3.4.4.1.6 Aerial Photography Interpretation

A comprehensive aerial photography report was completed in 1994 (Ebert and Associates November 1994). The aerial photographs show that noncentrifuge construction debris was dumped at SWMU 228A before November 1951. The centrifuge (SWMU 50) was constructed in 1952. Two concrete slabs that subsequently were labeled in 1994 as radioactive anomalies 228E1 and 228E2 are evident in a 1959 aerial photograph. Except for the construction of the ECF outfall system in the early 1990s and the erosion of the Scrappy-DU gully in July 1997, the vicinity of SWMUs 50 and 228A had not changed significantly from 1956 until the VCM cleanup operation.

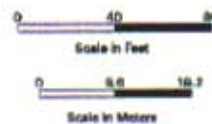
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Legend

	2 Foot Contour		Radioactive (DU) Anomaly
	Unpaved Road		Metallic Anomaly
	Survey Boundary		Construction Debris
	Diversion Ditch		Scooby-DU
	Bunker / Outfall		Scrappy-DU Gully
	SWMU 228A & 50		Alluvial Fan
	Buried Test Debris		
	Clean Fill Ridge		

Figure 3.4.4-1
Compilation of Radioactive & Metallic Anomalies for VCM Remediation at SWMU 228A



Sandia National Laboratories, New Mexico
Environmental Geographic Information System

3.4.4.1.7 *Soil-Vapor Survey*

Soil-vapor sampling was conducted at SWMU 228A in 1995. Two Petrex passive soil-vapor collectors (SVS-014 and SVS-015) were buried for 15 days near radioactive anomalies 228E1 and 228E2 at the north end of Scrappy-DU gully (Figure 3.4.3-1). After retrieval, the collectors were analyzed by thermal desorption/mass spectrometry (NERI October 1995). The analytes consisted of the two volatile organic compounds (VOC)—perchloroethylene (PCE) and trichloroethylene (TCE). Petrex location SVS-014 yielded low VOC levels, with 2,229 total ion counts (tics) for PCE; TCE was not detected. Petrex location SVS-015 yielded 1,929,050 tics of PCE and 309,448 tics of TCE.

In 1997 soil vapor samples were collected at four locations (SVS-301 through SVS-304) using VaporTec passive soil vapor collectors (Figure 3.4.3-1). The collectors were buried for 21 days. After retrieval, the collectors were analyzed by gas chromatography using modified EPA Methods 8021/8015 (EPA November 1986, TEG 1998). The collectors were analyzed for benzene, toluene, ethylbenzene, xylenes, total petroleum hydrocarbons (TPH) (gasoline range), TPH (diesel range), and chlorinated solvents. Benzene, toluene, and ethylbenzene were detected at a maximum of 1.12, 4.61, and 1.97 nanograms (trillionths of a gram), respectively. Xylenes were not detected. The reportings of TPH-gasoline and TPH-diesel values are not considered valid because these two analytes were also detected in the trip blank. Only one chlorinated solvent (1,1,2-trichloroethane [TCA]) was detected. However, the value of 4.4 nanograms for 1,1,2-TCA was not confirmed in the duplicate collector, which yielded no detectable VOCs.

The low levels of organic compounds detected by the Petrex and VaporTec collectors implied that corresponding soil samples would not contain concentrations of VOCs or SVOCs in excess of 1 milligram (mg)/kilogram (kg) parts per million (Viellenave June 1998).

3.4.4.1.8 *Geophysical surveys*

During late 1997 and early 1998, two geophysical surveys were conducted across most of SWMU 228A, excluding the Scrappy-DU gully (MDM/Lamb, Inc., February 1998). The gully was not surveyed because the steep walls were potentially unstable. To ensure continuous coverage across the remainder of the site, a grid spacing of 3 feet was used to guide the operator along each geophysical traverse. Two techniques, magnetic field strength mapping and electromagnetic (EM) metal detection, were used. The total magnetic field of ferrous (iron and steel) objects was measured with a hand-held Geometrics G-858 cesium vapor magnetometer. The G-858 data were acquired approximately every 0.75 foot along each traverse. Ferrous and nonferrous metallic objects were mapped with a Geonics EM-61 high-precision metal detector, which was mounted on a two-wheel carriage. The EM-61 data were acquired approximately every 0.6 foot along each traverse. Because the EM-61 is a bulkier instrument than the G-858, it was used to survey a slightly smaller portion of the site where the terrain was too steep for the carriage. The geophysical surveys identified several locations where metallic debris was buried (Figure 3.4.4-1).

3.4.4.2 Project Sampling Data Collection

3.4.4.2.1 Site-Specific Background Sampling

No site-specific background sampling was conducted for SWMU 228A. Instead, the HRMB-approved background values are used for this NFA proposal.

3.4.4.2.2 Scoping Sampling

No scoping sampling results are applicable to SWMU 228A. Recent geophysical surveys have shown that a series of 1995 GeoProbe boreholes previously reported in the SWMU 228A VCM Plan were in fact not useful. The boreholes were located too far north to characterize the true locations of buried debris and contaminated soil in the Scrappy-DU gully. Furthermore, the lack of field documentation and adequate laboratory quality assurance (QA)/quality control (QC) procedures for the borehole data rendered the scoping sampling results too unreliable for use.

3.4.4.2.3 Boundary Sampling

In August 1997 the SNL/NM Environmental Monitoring Department collected 14 surface soil samples outside the boundary of SWMU 228A. Most of these RP-series samples were collected on the floodplain below the site (Figure 3.4.3-1). The samples were analyzed for gamma emitters by the RPSD laboratory with MDAs for DU (uranium-238) that ranged from 1.72 to 4.29 pCi/g (Annex 3-B). No radioactive contamination was identified in the soil samples.

3.4.4.3 Data Gaps

This investigation provided a firm understanding of the remediation problems that remained at SWMU 228A.

3.4.4.4 Results and Conclusions

Investigation #3 identified the remediation areas for SWMU 228A.

3.4.5 Investigation #4—VCM Remediation

3.4.5.1 Nonsampling Data Collection

Investigation #4 consisted of the VCM remediation at SWMU 228A. No non-sampling data collection activities were conducted as part of Investigation #4.

3.4.5.1.1 Archival research

No additional archival research was conducted during this investigation.

3.4.5.2 *Sampling Data Collection*

The sampling data collection activities for Investigation #4 included VCM activities and NFA confirmatory sampling, as described in this section.

3.4.5.2.1 *VCM Remediation Activities*

The purpose of the SWMU 228A VCM was to completely remediate the entire site, rendering it suitable for continued industrial use as a buffer zone. Prior to the start of the VCM remediation, the SWMU 228A VCM Plan was submitted to the NMED in June 1998 (SNL/NM May 1998).

Permits

Interagency permits such as a Topsoil Disturbance Permit were obtained from the City of Albuquerque (COA). Even though part of the site is located on the Tijeras Arroyo floodplain, a U.S. Army Corps of Engineers permit was not required for excavating the site (Fink March 1998, Manger February 1998). However, the construction and maintenance of surface-water controls were conducted in accordance with NMED surface-water erosion guidance (NMED June 1993, NMED July 1997). In accordance with the National Environmental Policy Act, a review of the potential impacts of the VCM remediation was filed with SNL/NM (SNL/NM November 1997). Miscellaneous permits such as a penetration/dig permit were obtained from SNL/NM Facilities Engineering.

Strategy

The principal VCM activities were (1) the excavation of DU fragments, DU-contaminated soil, weapons debris, and construction debris; (2) segregation of waste into hazardous, radioactive, mixed, or nonregulated solid waste; and (3) confirmatory sampling.

Figure 3.4.4-1 is a compilation of the visual observations, aerial photography, geophysical surveys, and radiological surveys that defined the remediation area for SWMU 228A (SNL/NM May 1998). The remediation was conducted at four areas:

- The construction debris area,
- The buried test debris area,
- The Scrappy-DU gully, and
- Scooby-DU.

Before the excavation work began, the potential COCs for SWMU 228A were DU, nonfriable asbestos, cadmium, lead, RDX, VOCs, and SVOCs. These COCs were based upon sampling results, memoranda, and visual observations. DU is the only radionuclide known to have been used at the centrifuge (Green January 1998). Numerous gamma spectroscopy results for soil and debris had identified DU (uranium-238) as the sole radionuclide of concern. The potential VOCs were PCE; TCE; bromochloromethane; methylene chloride (dichloromethane); and

1,1,1-TCA. PCE and TCE were inferred from soil vapor results. The last three VOCs (bromochloromethane; methylene chloride; and 1,1,1-TCA) were inferred from recent Material Safety Data Sheets to have been the solvents present in the 1950s-vintage Stresscoat lacquer that had been painted on some test units prior to testing. The SVOCs were inferred from the soil-vapor TPH results.

The strategy for defining the vertical and lateral extent of each excavation or area was to continue excavating until:

- No visible DU or debris remained,
- Radiological surveys indicated that no radioactive contamination was present in excess of 1.3 times background,
- Metal detector surveys indicated that no metallic debris remained buried,
- No organic vapors were detected by a photoionization detector (PID), and
- Geologic evidence was found to distinguish natural deposits from fill material.

The principal VCM Proposed Cleanup Value was 271 pCi/g of DU in soil. The cleanup goals were risk-based preliminary remediation goals (PRG) from the VCM Plan (SNL/NM May 1998). Fortunately, the DU fragments were quite visible because the DU was typically weathered to a yellowish oxidized state known as *schöepite*. Similarly, DU fragments were easily detected in the field with radiation instruments. As a result, the VCM remediation achieved a site cleanup that was far below the PRG for DU.

Laydown work was conducted for all excavated material at SWMU 228A except for the soil and debris that was buried at the northern end of Scrappy-DU gully. Instead of being sorted through the grizzly, each load of this material was field-screened while in the excavator bucket. The material was then directly dumped into a series of 12 rectangular metal boxes. This material contained such significant amounts of DU that waste segregation was impractical.

The laydown work for separating the debris from soil was labor-intensive. After the visible debris was removed from a particular area, a backhoe was used to dump the soil and any remaining debris onto one of the two grizzlies. Each grizzly was 10 feet wide and constructed of steel bars set 6 inches apart. Cobbles and large pieces of debris were, thus, diverted from the bulk of the soil. The northernmost grizzly was used in the laydown area for sorting soil from the Buried Test Debris Area and the Construction Debris Area. The second grizzly was located at the southern part of the site in the oversize area and was used for removing large items from the DU-contaminated soil that was subsequently processed by the Segmented Gate System (SGS).

The laydown work allowed each load of soil to be spread out evenly in 3-inch lifts. Each lift of soil and debris was subsequently screened with radiation detectors and a PID. All radioactive material (DU fragments and DU-contaminated debris) was manually segregated from nonradioactive material and managed separately. Unique items such as the nonfriable asbestos pieces (Transite™ sheets and hardened Mastic™ glue) were quite distinctive and were hand-picked from the soil and subsequently containerized. Scrap metal and lead sheets were separately containerized for eventual recycling. Nonregulated material such as lumber, trash,

and glass also was containerized for off-site disposal. No debris of any sort was left at SWMU 228A. The remaining laydown soil was placed in various soil piles for subsequent sampling.

Most of the radiological screening of soil and debris was conducted by radiological control technicians (RCT) from SNL/NM Radiation Protection. A variety of hand-held instruments were used. All material was screened for radioactivity with a sodium iodide detector (ESP-2 with sodium iodide) and a Geiger-Mueller (GM) Pancake Probe/Frisker Model ASP-1 with HP-260. The sodium-iodide detector measured gamma emitters and the GM pancake frisker measured beta/gamma emitters. A Bicon B221L microrem meter also was used for surveying the beta/gamma levels of the material placed in the waste containers. Soil from the alluvial fan also was surveyed by an automated gamma detector array in the Thermo NUtech, Inc., SGS. For verification purposes, the field-screening results were compared to debris swipes that were analyzed by the RPSD laboratory.

Other field instruments aided the remediation effort. Soil and debris were screened for organic compounds using a PID (ThermoEnvironmental Inc. Organic Vapor Monitor Model 580B). Surveying for buried metal was conducted using a military-grade metal detector (Vallon Model ML-1620).

Chronology

Following site setup, the excavation work for the VCM remediation began in July 1998. Table 3.4.5-1 presents a chronology of the VCM activities at SWMU 228A. The VCM activities involved about 12 months of field work. Figures 3.4.5-1 through 3.4.5-6 are a series of photographs depicting some of the more interesting aspects of the VCM activities.

Heavy Equipment Activities Involving Debris Removal

The soil excavation work for excavating debris and DU fragments was conducted over a period of 6 weeks with heavy equipment: a trackhoe excavator, a backhoe, and three front-end loaders. The majority of the excavation work was concentrated at Scooby-DU and the Scrappy-DU gully. Remediation of these two areas primarily involved the excavation of approximately 1,400 cubic yards of soil, gravel, cobbles, weapons debris, and DU fragments. The visible DU fragments ranged from sand size to softball size.

The excavation of the Scrappy-DU gully was complicated because the gully was nearly surrounded by concrete slabs and had steeply sloping walls. The long reach of the trackhoe excavator was ideal for excavating the gully. Figure 3.4.5-7 presents a cross-sectional view of the gully. The original dump site for the DU fragments was found to underlie a series of black rubber pads that were located on the west side of the gully at an approximate elevation of 5,401 feet above mean sea level (amsl) (Figure 3.4.5-7). During the excavation work radiation surveys were conducted (Figure 3.4.5-3). The gully was excavated well below the original extent of debris and DU fragments to a final elevation of approximately 5,393 feet amsl. The total volume of soil and debris placed into the rectangular metal boxes was 48 cubic yards. Soil comprised about 41 cubic yards of this volume. Construction debris accounted for about 6 cubic yards; the remaining 1 cubic yard was weapons debris, including an estimated 300 pounds of DU.

Table 3.4.5-1
Chronology of VCM Remediation Activities Conducted at SWMU 228A

Remediation activity	Date of activity
<ul style="list-style-type: none"> Excavation of the Construction Debris Area Sorting of soil and construction debris Building Soil Pile #1 Containerizing waste 	7/13/98–7/21/98
<ul style="list-style-type: none"> Excavation of the Buried Test Debris Area Sorting of soil and construction debris Building Soil Pile #2 Containerizing waste 	7/22/98–7/28/98
<ul style="list-style-type: none"> Excavation of the Scrappy-DU gully Sorting of soil and construction and weapons debris Building Soil Pile #3 Containerizing waste 	7/29/98–7/31/98
<ul style="list-style-type: none"> Sorting of Scooby-DU soil to remove cobbles and debris Building Soil Pile #4 with soil containing DU 	8/3/98–8/13/98
<ul style="list-style-type: none"> Waste management of debris containers at north end of site 	7/13/98–9/14/98
<ul style="list-style-type: none"> Collection of soil samples TJAOU-228A-GR-120-S through TJAOU-228A-GR-150-S at north end of site (Buried Test Debris Area, Construction Debris Area, Soil Piles #1, #2, and #3) 	9/8/98
<ul style="list-style-type: none"> SGS processing of Soil Pile #4 to remove DU Contaminated soil and DU fragments placed in drums Soil Pile #5 built with "cold" (clean) soil Building Soil Pile #6 using soil from SGS loader ramp 	11/6/98–11/17/98
<ul style="list-style-type: none"> Collection of soil samples TJAOU-228A-GR-151-S through TJAOU-228A-GR-228-S along Scrappy-DU gully, across Scooby-DU fan and from Soil Piles #5 and #6 	12/1/98–12/3/98
<ul style="list-style-type: none"> Collection of soil samples TJAOU-228A-GR-229-S through TJAOU-228A-GR-249-S at nondebris areas 	2/15/99
<ul style="list-style-type: none"> Surveying of oversize material left from SGS operation 	3/15/99–3/16/99
<ul style="list-style-type: none"> Conducting confirmatory geophysics 	2/25/99–3/5/99
<ul style="list-style-type: none"> Redepositing Soil Piles #1, #2, #3 and regrading north part of site 	3/18/99–3/19/99
<ul style="list-style-type: none"> Waste management for Scooby-DU debris 	8/3/98–6/30/99
<ul style="list-style-type: none"> Redeposition of Soil Piles #5 and #6 across center part of SWMU 228A and final grading at SWMU 228A and SWMU 50 	7/12/99–7/15/99
<ul style="list-style-type: none"> Revegetating SWMU 228A and vicinity of SWMU 50 	7/29/99–7/31/99

DU = Depleted uranium.

SGS = Segmented Gate System.

SWMU = Solid Waste Management Unit.

VCM = Voluntary corrective measure.

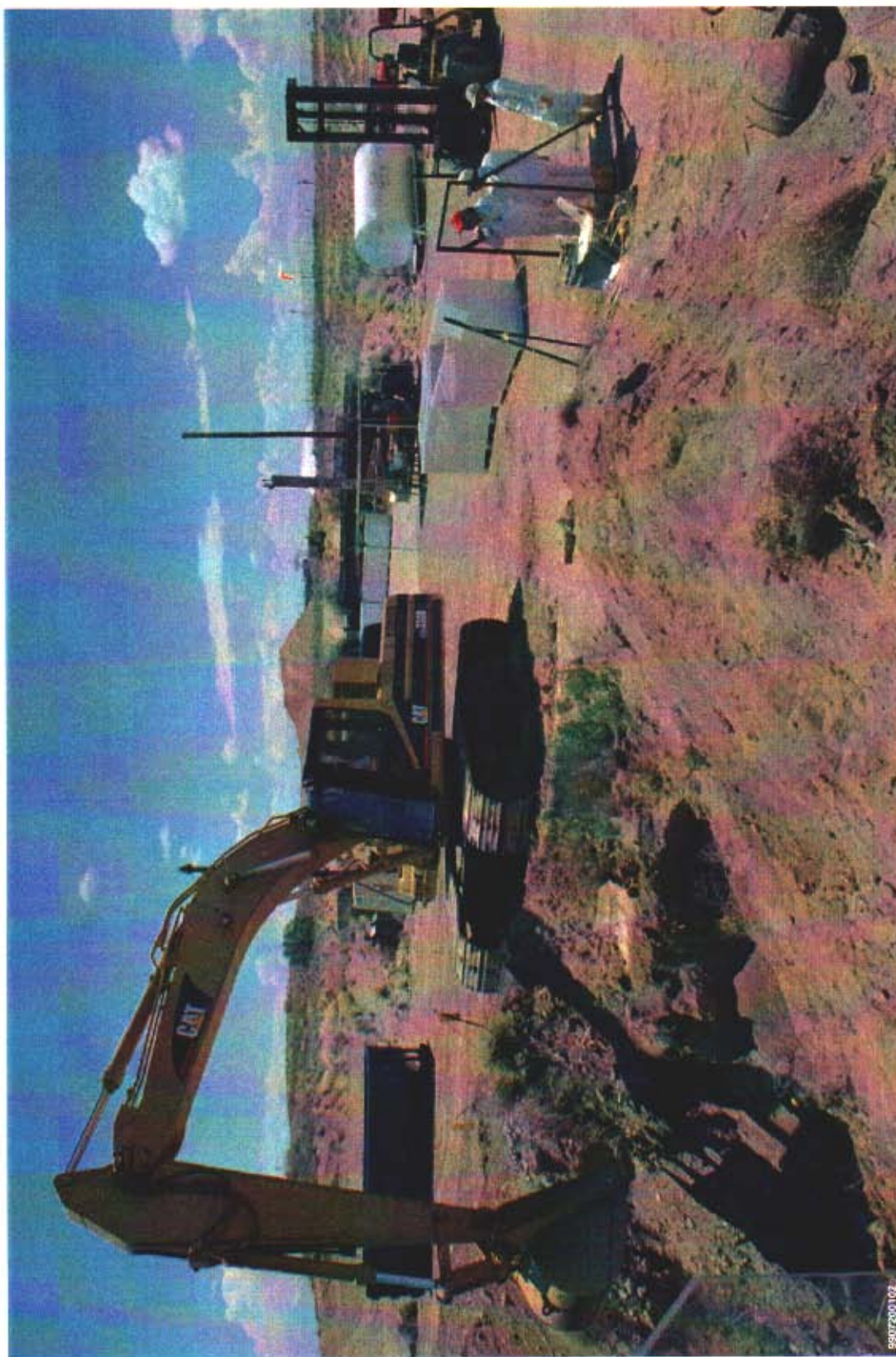


Figure 3.4.5-1
July 1998 photograph during the Voluntary Corrective Measure remedial activity at SWMU 228A. The excavator is removing weapon debris from the west side of Scrappy-DU gully.



Figure 3.4.5-2
July 1998 photograph with a Radiological Control Technician surveying SWMU 228A weapon debris at Scrappy-DU with a Bicron μ rem radiation meter. The weapons debris consists of black rubber pads and yellow DU fragments.



Figure 3.4.5-3

July 1998 photograph with a Radiological Control Technician surveying the ground surface at SWMU 228A after the removal of the weapons debris shown in Figure 3.4.5-2. The technician is using a Sodium-iodide radiation detector.

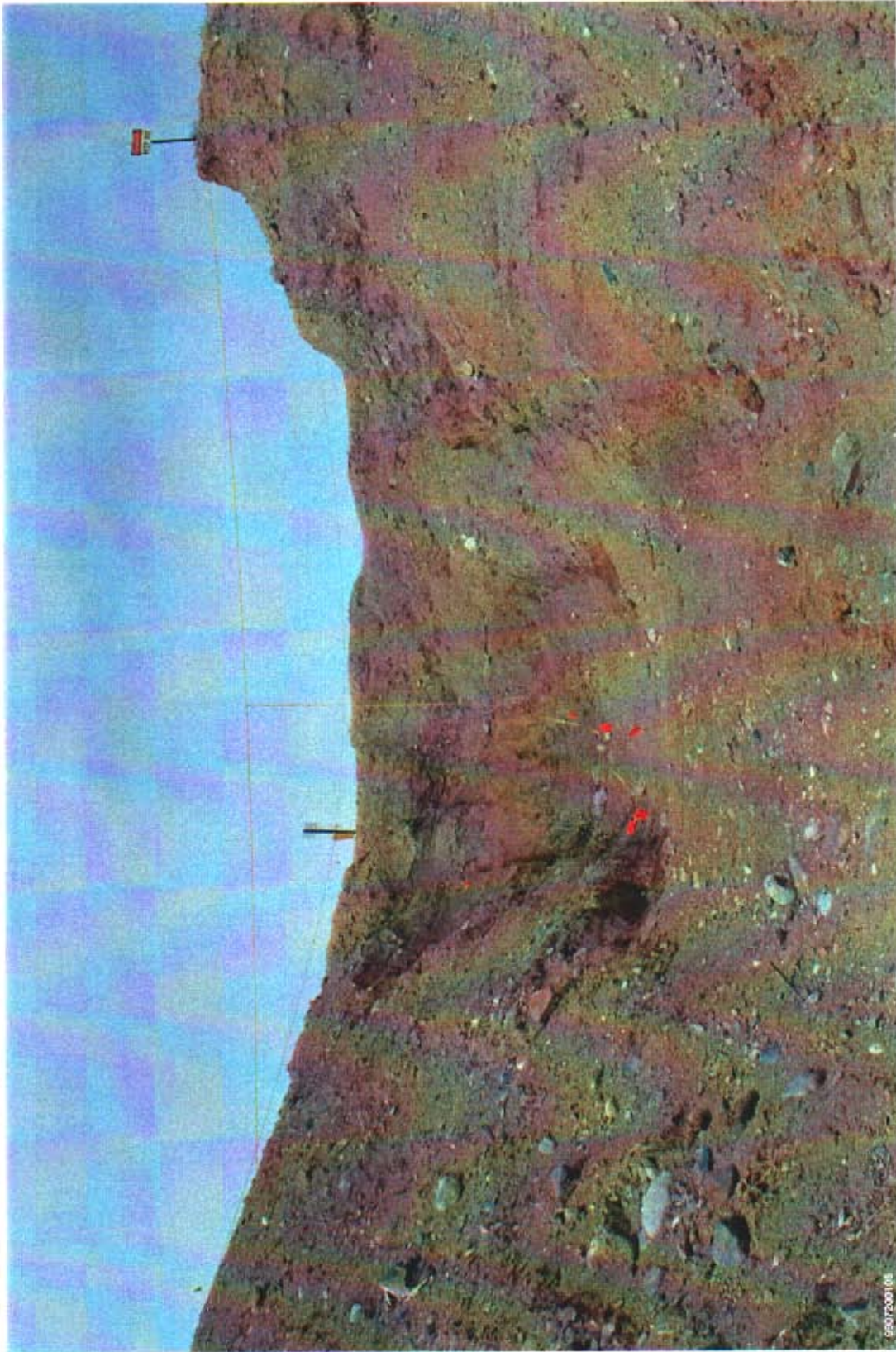


Figure 3.4.5-4
February 1999 photograph of the gully at SWMU 228A after all the debris was removed and confirmatory work conducted. Cobbles are scattered across the area.

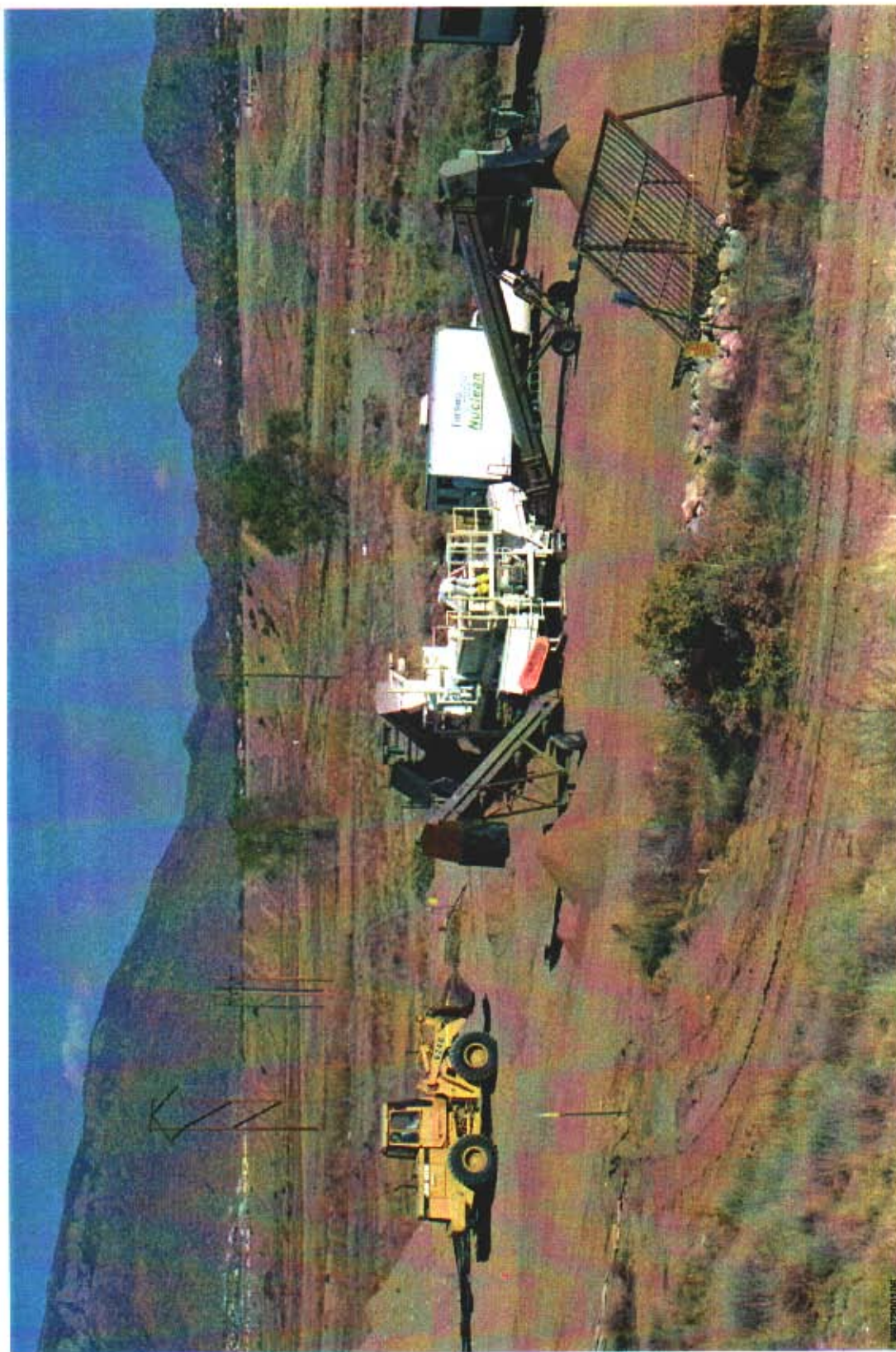
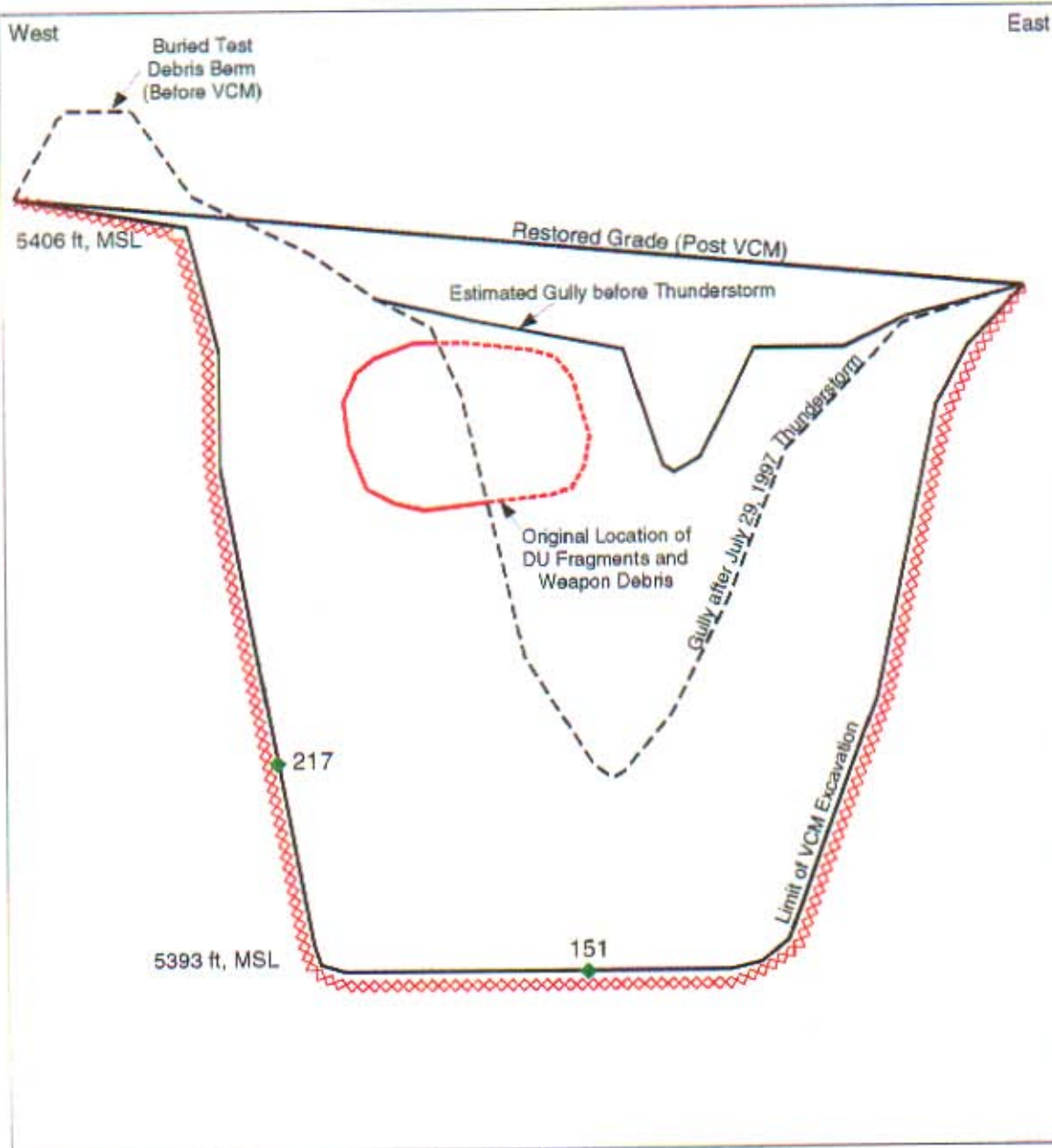


Figure 3.4.5-5

November 1998 photograph of the Thermo NUtech Inc. Segmented Gate System processing the DU-contaminated soil at SWMU 228A. Cold-pile soil is shown exiting the below-criteria conveyor belt in the center of the photograph. Hot-pile soil with DU fragments is discharging from the above-criteria conveyor belt on the right.



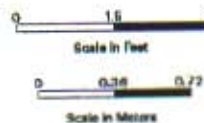
Figure 3.4.5-6
March 1999 photograph of the northern end of SWMU 228A after completion of the confirmatory work.
A pair of backhoes are restoring the natural grade.



Legend

- ◆ Confirmatory Soil Sample (TJAOU-228A-###-S)
- Original Location of DU Fragments & Weapon Debris
- Various Stages of Gully Profile
- Radiological Survey

**Figure 3.4.5-7
West-East Schematic across
Scrappy-DU Gully**



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Environmental Geographic Information System

Excavating the vicinity of Scooby-DU was relatively straightforward because the alluvial fan was deposited on the nearly flat floodplain. The alluvial fan covered about 0.4 acre and had a maximum width of about 150 feet with a maximum thickness of about 3 feet. A pair of front-end loaders scraped up the DU-contaminated soil and dumped the soil into a grizzly. The grizzly sorted out about 100 cubic yards of cobbles and a few large pieces of debris from the soil. The sorted soil was stockpiled as Soil Pile #4 until the SGS was operational.

As various parts of SWMU 228A were excavated, surface-water runoff controls were used intermittently. The controls consisted of silt fences, straw bales, and a diversion ditch. Even though most of the excavation work was done during the monsoon season and thunderstorms were an occasional concern, the surface-water runoff controls were a superfluous precaution because virtually all of the rainfall quickly infiltrated the soil. For example, the 4 inches of rain that fell in July 1998 did not create enough surface-water runoff to affect the remediation areas adversely.

SGS Operation

In November 1998 Soil Pile #4 was processed with the Thermo NUtech, Inc., SGS. The SGS is a computer-controlled system of radiation detectors and conveyor belts that automatically segregates radioactively contaminated debris and soil from a moving feed supply of soil (Annex 3-C) (Thermo NUtech, Inc., December 1998). For SWMU 228A, the SGS was equipped with an array of gamma detectors that were calibrated to the radioactive signature of DU. The SGS segregation level was conservatively set at 27 pCi/g, which was one-tenth the VCM proposed cleanup value of 271 pCi/g (SNL/NM May 1998). The DU-contaminated soil was diverted by a series of segmented gates to a "hot" pile for subsequent containerization.

As a result of the SGS processing, the volume of Soil Pile #4 was reduced by 99.6 percent. The resulting "cold" pile had a volume of 1,347 cubic yards. The "hot" pile had a volume of 5 cubic yards. The "hot" pile soil was subsequently transferred to 21 55-gallon drums for eventual shipment to a permitted waste disposal facility.

Gamma spectroscopy data from General Engineering Laboratory (GEL) and the SNL/NM RPSD laboratory were used for characterizing the DU content of the "cold" pile. The gamma spectroscopy data from GEL yielded an average for the eight samples of 2.15 pCi/g. The two RPSD samples averaged 4.7 pCi/g of DU. Therefore, the average DU activity of all ten samples was 2.66 pCi/g. These ten samples represented the compositing of approximately 50 locations across the "cold" pile and are discussed further in the confirmatory soil sampling section. The averaged results from the SGS were similar at 14.77 pCi/g, which was based upon the continuous analysis of soil passing along the conveyor belt soil (Thermo NUtech, Inc., December 1998). A dose assessment using the gamma spectroscopy data and the DOE RESRAD computer code was performed for the "cold" pile (Miller May 1999) (Annex 3-G). The calculated dose for the soil was well below the standards set in DOE Order 5400.5 (DOE January 1993) and proposed EPA guidance (EPA August 1997). Following DOE concurrence (Soden and Rael July 1999) (Annex 3-H), the "cold" pile was used to grade the center portion of SWMU 228A. Grading activities are discussed in Section 3.4.5.2.3.

3.4.5.2.2 Waste Management

About 1,800 cubic yards of soil and debris were sorted with the grizzlies. Table 3.4.5-2 summarizes the types of debris handled during the segregation effort. The debris consisted of

Table 3.4.5-2
Types of Debris Generated at SWMU 228A

Construction Debris	Weapons Debris
Concrete rubble	DU fragments
Scrap metal (pipes, flat stock, wire, rebar, mesh)	12-inch-thick concrete slabs (228E1 and 228E2)
Scrap lumber	Weapons debris metal (mostly aluminum and steel)
Insulated wire	Rubber pads
Gypsum wallboard	Concrete sphere pieces
4-inch-thick concrete slabs	Nylon harness webbing and parachute material
Nonfriable asbestos (Transite™ and Mastic™)	Epoxy-encapsulated electrical junction boxes with micro electronics
Styrofoam™	Electrical wire cables
Glass bottles and window glass	Electrical connectors
Cloth scraps	Fiberglass sheets
Paper and cardboard	Nickel-cadmium (Ni-Cd) batteries

DU = Depleted uranium.

SWMU = Solid Waste Management Unit.

construction debris and weapons debris. Most of the weapons debris had been heavily damaged during the 1950s centrifuge tests. All of the debris was containerized and hauled to an off-site SNL/NM accumulation area pending shipment to an permitted disposal facility.

Several types of waste were not found during the VCM activities. For example, no UXO/HE was found at any of the remediation areas. No stained soil was observed and no organic vapors were detected with the PID. No friable asbestos was found. Likewise, no intact containers such as gas cylinders, drums, or paint cans were found during the excavation of SWMU 228A. No oil-filled electrical components were discovered.

From an approximate weight standpoint, the debris from SWMU 228A consisted of approximately 98 percent construction debris and approximately 2 percent weapons debris. Most of the construction debris consisted of concrete rubble and slabs. None of the construction debris (scrap metal, lumber, bricks, glass) was radioactively contaminated or oil-stained.

The total amount of DU fragments summarized in Table 3.4.5-3 represents five cleanup efforts. The first cleanup effort was conducted by RUST Geotech Inc., in which about 200 pounds of DU were collected (Section 3.4.4.1.3) (SNL/NM September 1997). In August 1997 another 25 pounds of DU fragments were collected from the ground surface of Scooby-DU. An estimated 300 pounds of DU fragments were placed in the rectangular metal boxes during the 1998 VCM activities. Another 10 pounds of DU fragments were manually picked out of the soil feed while the SGS was operating. During the final cleanup effort, about 70 pounds of DU fragments were gathered from the oversize area. The total weight of DU fragments removed from SWMU 228A was approximately 605 pounds. All of the DU fragments were collected from the Scrappy-DU gully or Scooby-DU. No DU fragments were found in the Buried Test Debris Area or the Construction Debris Area.

3.4.5.2.3 VCM Remediation Confirmatory Work

To verify that SWMU 228A was adequately remediated during the VCM, confirmatory work was conducted that consisted of soil sampling, geophysical surveys, and radiological surveys.

Table 3.4.5-3
Summary of Material Excavated During the Remediation of SWMU 228A

Excavated material	Approximate Volume or Weight	Waste Category
DU fragments	605 pounds	Low-level radioactive waste
DU-contaminated soil from gully	41 yd ³	Low-level radioactive waste
Weapons debris	2,350 pounds	Low-level radioactive waste
Construction debris (scrap metal, lumber, bricks, glass)	7 yd ³	Nonregulated
Concrete rubble	30 yd ³	Nonregulated
Concrete slabs	20 yd ³	Nonregulated
Lead piece with imbedded DU fragment	5 pounds	Mixed waste
Recyclable lead pieces	60 pounds	n.a., lead was recycled
Nonfriable asbestos pieces	1,000 pounds	Asbestos waste
Soil Piles #1, #2, #3	241 yd ³	n.a., soil was redeposited
Soil Pile #4 (Scooby-DU soil)	1,352 yd ³	n.a., soil was processed by SGS
Cobbles	100 yd ³	n.a., cobbles were redeposited
Soil Pile #5 ("cold" pile from SGS)	1,347 yd ³	n.a., soil was redeposited
"Hot"-pile soil (21 drums from SGS)	5 yd ³	Low-level radioactive waste
Soil Pile #6 (soil from loader ramp)	6 yd ³	n.a., soil was redeposited

DU = Depleted uranium.

n.a. = Not applicable.

SGS = Segmented Gate System.

SWMU = Solid Waste Management Unit.

yd = Cubic yard(s).

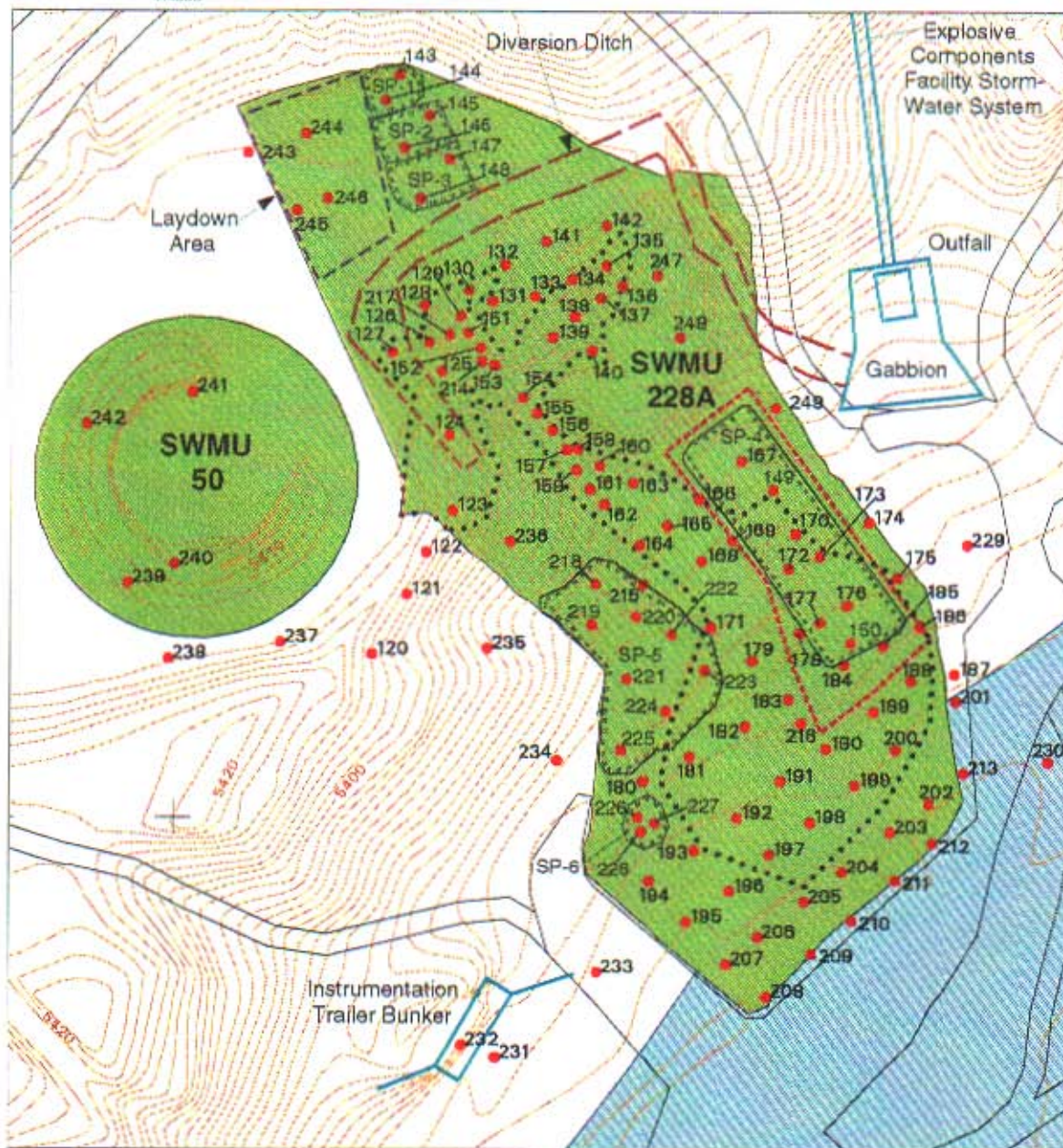
Confirmatory Soil Sampling

Following the conclusion of VCM remediation activity (excavation, debris removal, and radiological/metal-detector surveying) at a particular area, a series of confirmatory soil samples was collected. Confirmatory sampling was performed to determine whether potential COCs were present at levels exceeding background limits at the site and/or at levels sufficient to pose a risk to human health or the environment. The sampling activities were performed in accordance with the rationale and procedures described in the Field Implementation Plan (FIP) (SNL/NM July 1998) for SWMU 228A (see Annex 3-D). SNL/NM chain-of-custody and sample documentation procedures were followed for all samples that were collected.

The list of COCs for the confirmatory sampling was based upon the information available when the SWMU 228A FIP (SNL/NM July 1998) was written. The excavation and subsequent evaluation of the debris has revealed that the COC list was overly conservative. For example, no UXO/HE material was found. Likewise, no stained soil indicative of VOC or SVOC contamination was observed or detected with the PID. A few pieces of debris with either cadmium or lead material were observed; however, no debris was found to contain the other six RCRA metals. DU was the only radionuclide detected with the field instrumentation.

Confirmatory soil samples were collected at 130 locations across SWMU 228A and the vicinity; these samples were identified as TJAOU-228A-GR-120-S through TJAOU-228A-GR-249-S (Figure 3.4.5-8). Except for three samples, all of the samples were surface soil samples

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Legend

- Confirmatory Soil Sample (TJAOU-228A-GR-###-S)
- Unpaved Road
- 2 Foot Contour
- - - Laydown Area
- - - Diversion Ditch
- Bunker / Outfall
- - - Oversize Area (previous location)
- - - Soil Piles (SP-1,2,3,4,5,6) (previous locations)
- Lateral Extent of Excavated Debris

SWMU 228A & 50
100 Yr. Flood Plain

**Figure 3.4.5-8
VCM Confirmatory
Soil Sample Locations
at SWMU 228A**

0 40 80
Scale in Feet

0 9.8 19.7
Scale in Meters



Sandia National Laboratories, New Mexico
Environmental Geographic Information System

collected using a hand trowel from a depth of 0 to 0.5 foot bgs. Three additional samples (TJAOU-228A-GR-214-S through TJAOU-228A-GR-216-S) were collected from random locations using a hand auger from a depth of 2 to 3 feet bgs.

A total of 118 soil samples (plus six equipment blanks) were analyzed off site for radionuclides using gamma spectroscopy. Isotopic uranium analyses were also performed off site on an additional 56 soil samples (plus five equipment blanks and one trip blank). Sixty-eight samples (plus five equipment blanks) were analyzed off site for RCRA metals; 22 of these samples included an analysis for total uranium. Thirty-five samples (plus five equipment blanks) were analyzed off site for HE and SVOC compounds. These same 35 samples (plus 4 equipment blanks and 4 trip blanks) were analyzed off site for VOC compounds. The RPSD Laboratory analyzed 56 samples (plus one equipment blank) for radionuclides using gamma spectroscopy.

QA/QC samples included nine duplicate soil samples, six equipment blanks, and four trip blanks. Duplicates were collected at 10 percent of the sampling locations in the former debris areas. Equipment-wash (aqueous rinsate) blanks were prepared at the end of each sampling day.

Two off-site laboratories conducted the analyses: GEL in Charleston, South Carolina, and Core Laboratories, Inc., in Denver, Colorado. Table 3.4.5-4 summarizes the analytical methods used by each laboratory.

Table 3.4.5-4
Summary of Analytical Methods Used for SWMU 228A
Confirmatory Soil Samples

Analyte	Analytical Method	Analytical Laboratory
Radionuclides	EPA 901.1 ^a (gamma spectroscopy)	Core, GEL, RPSD
Isotopic uranium	SGAMMA, HASL300, EPI A-011B	Core, GEL
RCRA metals	6010/7000 series ^a	Core, GEL
Total uranium	908.1 ^a	Core, GEL
VOCs	8260 ^a	Core, GEL
SVOCs	8270 ^a	Core, GEL
HE compounds	8330 ^a	Core, GEL

^aEPA November 1986.

EPA = U.S. Environmental Protection Agency.

GEL = General Engineering Laboratory.

HE = High explosives.

RCRA = Resource Conservation and Recovery Act.

RPSD = Radiation Protection Sample Diagnostics.

SVOC = Semivolatile organic compound.

SWMU = Solid Waste Management Unit.

VOC = Volatile organic compound.

Final Geophysical Survey

Following the heavy equipment work, a confirmatory geophysical survey was conducted across SWMU 228A (MDM/Lamb April 1999). The survey was conducted using both a Schonstedt 72-C magnetic locator and a Garrett CXII metal detector with depth multiplying antennae. During the survey work, several pieces of scrap metal were collected. At the conclusion of the survey, no metallic debris remained at SWMU 228A (MDM/Lamb April 1999).

Final Radiological Survey

Following the completion of the heavy equipment work, a final series of radiological surveys was conducted to verify that no radiological anomalies such as DU fragments remained at SWMU 228A. The walkover surveys were conducted by RCTs using sodium iodide detectors and a 3-foot grid spacing that ensured 100 percent coverage of the ground surface. The radiological surveys confirmed that no radioactive anomalies remained at SWMU 228A (SNL/NM August 1998, SNL/NM March 1999).

Final Site Grading, Surface-Water Controls, and Revegetation

After the soil sample results were reviewed and the final round of geophysical and radiological surveys were conducted, SWMU 228A was regraded. The 241 cubic yards of soil from Piles #1, #2, and 3 were used to fill in the gully so that it blended in with the surrounding arroyo rim. Soil Piles #5 and #6 were used to regrade the center portion of the site from the mouth of the gully down to the edge of the 500-year floodplain for Tijeras Arroyo. The total volume of Soil Piles #5 and #6 was 1,353 cubic yards of soil; the resulting layer of soil covered approximately 0.8 acre with an average thickness of approximately 1.2 feet.

The final grading at SWMU 228A was designed to eliminate the potential for surface-water runoff and run on. For example, the ground surface was sloped to divert water away from the gully. A bulldozer was used to extend the diversion ditch across the northern part of SWMU 228A and the eastern side of the SWMU 50 centrifuge (Figure 3.4.5-8). This diversion ditch has eliminated the potential for water to pond as it had during the July 1997 erosion and washout of debris.

After final grading was complete, revegetation work was performed in accordance with COA guidance (COA February 1996). The Feed Bin, Inc., a COA-approved contractor, conducted the work during July 29-31, 1999. The seed mix was prepared by Curtis & Curtis, Inc. and included six native grasses (*Paloma* Indian rice grass, Sand dropseed, Florets *Viva* Galleta grass, Lehmanns lovegrass, Alkali Sacaton, and Four-wing Saltbush) and two wildflowers (Aristata Firewheel Gaillardia and Appar Lewis Blue Flax). A total of three acres was revegetated (Figures 3.4.5-9 and 3.4.5-10). In addition to revegetating the SWMU 228A excavated/disturbed areas which totaled about 1.5 acres, an additional 1.5 acres west and northwest of SWMU 228A in the vicinity of the SWMU 50 centrifuge were revegetated. Depending on the slope, either drill seeding or hydroseeding was done. Level areas and areas with slopes less than 3:1 (horizontal versus vertical) were drill seeded using a series of farm implements to disc, fertilize, and lastly crimp the seed and straw mulch to a depth of 0.5 inch.



Figure 3.4.5-9

August 1999 photograph of SWMU 228A after final grading and revegetation work. View is to the northwest. Straw mulch is visible across the center of the site. Erosion control mats are visible in the gully.



Figure 3.4.5-10

August 1999 photograph of SWMU 228A after final grading and revegetation work. View is to the southwest along the rim of Tijeras Arroyo. The Explosives Components Facility outfall is visible in the left foreground with the centrifuge at SWMU 50 being visible in the right foreground.

Slopes steeper than 3:1 were revegetated using the broadcast method in which a hydroseed mixture of fertilizer, wood fiber, seed, and tackifier was sprayed across the slopes. The broadcast areas were then hand raked to a depth of 0.5 inch and covered with Excelsior™ erosion-control mats consisting of wood shavings enclosed in fiber mesh. The mats were secured to the ground with six-inch long wire staples.

The surface-water controls at SWMU 228A consist of the diversion ditch, the revegetated areas, and the erosion-control mats. Numerous site inspections during the unusually wet August 1999, monsoon season confirm that no off-site surface-water runoff or run on occurs at SWMU 228A; the rainfall infiltrates the soil well before off-site runoff or run on occurs. As a result of the approximately three inches of rain that fell during the two weeks following the revegetation work, the grass sprouted and grew nearly two inches in some locations. No significant erosion occurred.

3.4.5.3 *Data Gaps*

No data gaps remain for SWMU 228A.

3.4.5.4 *Results and Conclusions*

In September and December 1998 and February 1999, representative soil samples were collected from 130 confirmatory locations at SWMU 228A, all but three of which were surface soil samples. Tables 3.4.5-5 through 3.4.5-17 summarize the metals, HE, VOCs, SVOCs, and radionuclide (gamma spectroscopy and isotopic uranium) analytical results. Annex 3-E contains complete results for the gamma spectroscopy and isotopic analyses. Confirmatory sampling was performed across the site; each summary table of these samples include *site-confirmatory* in the title. Confirmatory sampling was also performed on the soil piles generated during VCM activities which were later used to regrade the site; each summary table for these samples includes *soil piles* in the title. For each analyte group, the site-confirmatory summary table is followed by the soil piles summary table.

An example sample identification (ID) in the ER sample ID column of the data summary tables is TJAOU-228A-GR-120-S. This ID reflects that the sample was collected from SWMU 228A within the Tijeras Arroyo Operable Unit (TJAOU). The soil sample (S) was a grab sample (GR) from Location 120. The following section briefly describes the results of confirmatory sampling at SWMU 228A.

Metals

Tables 3.4.5-5 and 3.4.5-6 summarize the off-site metals analytical results for both the site-confirmatory sampling (46 surface soil samples, 8 duplicate samples, and 5 equipment blank samples) and the soil piles sampling (13 surface soil samples and 1 duplicate sample).

Table 3.4.5-5
Summary of SWMU 228A Site-Confirmatory Sampling RCRA Metals Analytical Results, September-December 1998
(Off-Site Laboratories)

Metals (EPA Method 8010/7000) (mg/kg)												
Sample Attributes				Metals (EPA Method 8010/7000) (mg/kg)								
Record Number	ER Sample ID (Figure 3.4.5-8)	Date Sampled	Sample Depth (ft)	Arsenic	Barium	Cadmium	Chromium	Lead	Mercury	Selenium	Silver	Uranium
600799	TJAOU-228A-GR-120-S	9/8/98	0-0.5	2.79	138	ND (0.275)	7.97	6.04	ND (0.0078)	ND (0.0891)	ND (0.301)	31.7
600799	TJAOU-228A-GR-122-S	9/8/98	0-0.5	2.43	159	0.375 J (0.5)	7.30	7.89	ND (0.0078)	ND (0.0891)	ND (0.301)	22.3
600799	TJAOU-228A-GR-123-S	9/8/98	0-0.5	1.95	161	0.472 J (0.5)	9.33	7.76	ND (0.0078)	ND (0.0891)	ND (0.301)	32.6
600799	TJAOU-228A-GR-123-DU	9/8/98	0-0.5	2.05	137	ND (0.275)	8.21	6.83	ND (0.0078)	ND (0.0891)	ND (0.301)	20.7
600799	TJAOU-228A-GR-125-S	9/8/98	0-0.5	2.44	170	0.582	8.54	8.01	ND (0.0078)	ND (0.0891)	ND (0.301)	23.8
600799	TJAOU-228A-GR-127-S	9/8/98	0-0.5	2.11	160	0.452 J (0.5)	8.71	6.28	ND (0.0078)	ND (0.0891)	ND (0.301)	12.9
600799	TJAOU-228A-GR-129-S	9/8/98	0-0.5	2.14	133	1.28	8.97	40.5	ND (0.0078)	ND (0.0891)	ND (0.301)	83.9
600799	TJAOU-228A-GR-131-S	9/8/98	0-0.5	1.60	120	0.377 J (0.5)	10.8	7.60	ND (0.0078)	ND (0.0891)	ND (0.301)	16.8
600835	TJAOU-228A-GR-133-S	9/8/98	0-0.5	2.68	213	0.528	12.0	20.7	0.0080 J (0.10)	ND (0.0891)	ND (0.301)	32.3
600835	TJAOU-228A-GR-133-DU	9/8/98	0-0.5	2.76	184	ND (0.275)	10.4	0.217 J (1)	0.0122 J (0.10)	ND (0.0891)	ND (0.301)	19.4
600835	TJAOU-228A-GR-135-S	9/8/98	0-0.5	2.07	160	ND (0.275)	10.6	5.48	ND (0.0078)	0.127 J (0.5)	ND (0.00301)	18.6
600835	TJAOU-228A-GR-137-S	9/8/98	0-0.5	1.88	156	0.403 J (0.5)	10.7	5.90	0.0097 J (0.10)	0.108 J (0.5)	ND (0.301)	45.7
600835	TJAOU-228A-GR-139-S	9/8/98	0-0.5	2.77	194	0.442 J (0.5)	11.1	7.89	0.0081 J (0.10)	0.106 J (0.5)	ND (0.301)	28.1
600835	TJAOU-228A-GR-140-S	9/8/98	0-0.5	2.63	216	0.348 J (0.5)	11.3	20.1	0.0117 J (0.10)	0.109 J (0.5)	ND (0.301)	29.9
601188	TJAOU-228A-GR-151-S	12/1/98	0-0.5	2.69	102	ND (0.019)	8.02	8.33	0.0394	0.605	ND (0.031)	NR
601188	TJAOU-228A-GR-153-S	12/1/98	0-0.5	2.70	136	0.433 J (0.472)	7.59	7.89	0.0345	0.366 J (0.472)	0.155 J (0.472)	NR
601188	TJAOU-228A-GR-155-S	12/1/98	0-0.5	3.15	119	ND (0.019)	6.93	6.48	0.0315	0.531	ND (0.031)	NR
601188	TJAOU-228A-GR-157-S	12/1/98	0-0.5	2.74	125	ND (0.019)	6.43	6.99	0.0394	0.567	ND (0.031)	NR
601188	TJAOU-228A-GR-159-S	12/1/98	0-0.5	3.08	107	ND (0.019)	6.13	9.96	0.0296	0.540	0.103 J (0.476)	NR
601188	TJAOU-228A-GR-161-S	12/1/98	0-0.5	3.15	143	ND (0.019)	7.28	9.04	0.0246 J (0.0273)	0.918	ND (0.031)	NR
601188	TJAOU-228A-GR-161-DU	12/1/98	0-0.5	2.65	119	ND (0.019)	5.20	7.54	0.0260 J (0.0304)	0.506	ND (0.031)	NR
601189	TJAOU-228A-GR-163-S	12/1/98	0-0.5	1.98	89.7	ND (0.019)	6.72	36.5	0.0187 J (0.0251)	0.602	ND (0.031)	NR
601189	TJAOU-228A-GR-165-S	12/1/98	0-0.5	2.88	105	0.124 J (0.476)	6.15	6.55	0.0216 J (0.0309)	0.869	ND (0.031)	NR
601189	TJAOU-228A-GR-167-S	12/1/98	0-0.5	2.20	101	ND (0.019)	5.27	4.43	0.0213 J (0.0285)	0.528	ND (0.031)	NR
601189	TJAOU-228A-GR-169-S	12/1/98	0-0.5	2.09	117	ND (0.019)	5.70	5.88	0.0227 J (0.0297)	0.640	ND (0.031)	NR
601189	TJAOU-228A-GR-171-S	12/1/98	0-0.5	2.31	100	ND (0.019)	7.33	6.39	0.0252 J (0.0295)	0.875	ND (0.031)	NR
601189	TJAOU-228A-GR-171-DU	12/1/98	0-0.5	2.10	98.4	ND (0.019)	5.11	5.61	0.0252 J (0.0309)	0.813	ND (0.031)	NR
601189	TJAOU-228A-GR-173-S	12/1/98	0-0.5	2.25	98.9	ND (0.019)	5.66	5.54	0.0227 J (0.0313)	0.615	ND (0.031)	NR
601189	TJAOU-228A-GR-175-S	12/1/98	0-0.5	2.17	76.9	ND (0.019)	5.10	5.17	0.0220 J (0.0298)	0.774	ND (0.031)	NR
601190	TJAOU-228A-GR-177-S	12/2/98	0-0.5	2.29	135	ND (0.019)	6.49	5.56	0.0135 J (0.0314)	ND (0.135)	0.142 J (0.481)	NR
601190	TJAOU-228A-GR-179-S	12/2/98	0-0.5	2.14	104	ND (0.019)	5.20	8.54	0.00785 J (0.0302)	ND (0.135)	0.127 J (0.495)	NR
601190	TJAOU-228A-GR-181-S	12/2/98	0-0.5	2.21	110	ND (0.019)	5.52	7.65	0.0116 J (0.0304)	ND (0.135)	0.153 J (0.481)	NR
601190	TJAOU-228A-GR-181-DU	12/2/98	0-0.5	2.76	109	0.134 J (0.019)	6.20	7.66	0.0151 J (0.0297)	ND (0.135)	0.384 J (0.481)	NR
601190	TJAOU-228A-GR-183-S	12/2/98	0-0.5	2.81	144	0.115 J (0.500)	6.96	10.9	0.0182 J (0.0325)	ND (0.135)	0.144 J (0.500)	NR
601190	TJAOU-228A-GR-185-S	12/2/98	0-0.5	2.07	99.7	0.380 J (0.490)	5.92	8.42	0.0171 J (0.0328)	ND (0.135)	0.116 J (0.490)	NR

Refer to footnotes at end of table.

Table 3.4.5-5 (Continued)
Summary of SWMU 228A Site-Confirmatory Sampling RCRA Metals Analytical Results, September–December 1998
(Off-Site Laboratories)

Sample Attributes				Metals (EPA Method 6010/7000 ^a) (mg/kg)								
Record Number	ER Sample ID (Figure 3.4.5-8)	Date Sampled	Sample Depth (ft)	Arsenic	Barium	Cadmium	Chromium	Lead	Mercury	Selenium	Silver	Uranium
601190	TJAOU-228A-GR-187-S	12/2/98	0-0.5	2.57	98.2	ND (0.019)	6.81	6.94	0.00956 J (0.0313)	ND (0.135)	ND (0.031)	NR
601191	TJAOU-228A-GR-189-S	12/2/98	0-0.5	2.28	85.4 ^c	ND (0.019)	5.97	6.06	0.0204 J (0.0324) ^c	ND (0.135)	0.125 J (0.485) ^c	NR
601191	TJAOU-228A-GR-191-S	12/2/98	0-0.5	2.40	102 ^c	0.124 J (0.481)	6.85	7.68	0.0165 J (0.0292) ^c	ND (0.135)	0.209 J (0.481) ^c	NR
601191	TJAOU-228A-GR-191-DU	12/2/98	0-0.5	2.32	101 ^c	ND (0.019)	6.10	8.13	0.0185 J (0.0261) ^c	ND (0.135)	0.127 J (0.485) ^c	NR
601191	TJAOU-228A-GR-193-S	12/2/98	0-0.5	2.15	96.3 ^c	ND (0.019)	5.69	6.28	0.0327 ^c	ND (0.135)	0.154 J (0.481) ^c	NR
601191	TJAOU-228A-GR-195-S	12/2/98	0-0.5	2.53	97.1 ^c	ND (0.019)	6.96	5.55	0.0152 J (0.0314) ^c	ND (0.135)	0.118 (0.490) ^c	NR
601191	TJAOU-228A-GR-197-S	12/2/98	0-0.5	2.28	101 ^c	ND (0.019)	5.94	6.50	0.0158 J (0.0329) ^c	ND (0.135)	0.168 J (0.490) ^c	NR
601191	TJAOU-228A-GR-199-S	12/2/98	0-0.5	2.62	99.3 ^c	0.337 J (0.495)	6.85	7.45	0.0138 J (0.0301) ^c	ND (0.135)	0.151 J (0.495) ^c	NR
601192	TJAOU-228A-GR-201-S	12/3/98	0-0.5	2.34	98.4	ND (0.019)	6.80	9.12	ND (0.00225)	0.494 J (0.495)	0.0685 J (0.495)	NR
601192	TJAOU-228A-GR-201-DU	12/3/98	0-0.5	2.34	88.5	ND (0.019)	6.58	8.71	ND (0.00225)	0.374 J (0.495)	ND (0.031)	NR
601192	TJAOU-228A-GR-203-S	12/3/98	0-0.5	2.27	119	ND (0.019)	8.33	6.65	ND (0.00225)	0.381 J (0.500)	ND (0.031)	NR
601192	TJAOU-228A-GR-205-S	12/3/98	0-0.5	2.15	95.6	0.0584 J (0.500)	5.65	7.03	0.00234 J (0.0275)	0.365 J (0.500)	0.0773 J (0.500)	NR
601192	TJAOU-228A-GR-207-S	12/3/98	0-0.5	2.38	138	ND (0.019)	6.47	6.36	ND (0.00225)	0.333 J (0.495)	0.0605 J (0.495)	NR
601192	TJAOU-228A-GR-209-S	12/3/98	0-0.5	3.25	168	1.77	9.48	21.9	ND (0.00225)	0.465 J (0.490)	0.436 J (0.490)	NR
601192	TJAOU-228A-GR-211-S	12/3/98	0-0.5	2.28	116	ND (0.019)	7.01	6.37	ND (0.00225)	0.311 J (0.490)	ND (0.031)	NR
601192	TJAOU-228A-GR-211-DU	12/3/98	0-0.5	2.67	113	ND (0.019)	5.42	6.54	ND (0.00225)	0.581	ND (0.031)	NR
601212	TJAOU-228A-GR-213-S	12/3/98	0-0.5	2.44	122	ND (0.019)	6.35	7.00	ND (0.00225)	0.402 J (0.495)	ND (0.031)	NR
601212	TJAOU-228A-GR-215-S	12/3/98	2-3	1.79	84.3	ND (0.019)	4.62	4.81	ND (0.00225)	0.358 J (0.495)	ND (0.031)	NR
601212	TJAOU-228A-GR-217-S	12/3/98	0-0.5	1.69	80.9	ND (0.019)	7.47	5.26	ND (0.00225)	0.275 J (0.485)	ND (0.031)	NR
Background Soil Concentrations—North Supergroup ^a				4.4	200	0.9	12.8	11.2	<0.1	<1	<1	2.3
Quality Assurance/Quality Control Samples (mg/L)												
600836	TJAOU-228A-GR-EB	9/8/98	NA	ND (0.000827)	ND	ND (0.002752)	0.00216 J (0.01)	0.00138 J (0.002)	ND (0.000047)	ND (0.000891)	ND (0.003007)	NR
600836	TJAOU-228A-GR-EB	9/9/98	NA	ND (0.000827)	ND	ND (0.002752)	ND (0.001985)	ND	ND (0.000047)	ND (0.000891)	ND (0.003007)	NR
601189	TJAOU-228A-EB	12/1/98	NA	ND (0.00451)	0.00189 J (0.00500)	ND (0.00044)	0.00532	0.00924	ND (0.000035)	ND (0.00271)	0.00105 J (0.00500)	NR
601191	TJAOU-228A-EB	12/2/98	NA	ND (0.00451)	0.00126 J (0.00500)	ND (0.00044)	0.00209 J (0.00500)	0.00401 J	ND (0.000035)	ND (0.00271)	0.00104 J (0.00500)	NR
601212	TJAOU-228A-EB	12/3/98	NA	ND (0.00451)	0.00200 J (0.00500)	ND (0.00044)	0.00148 J (0.00500) ^a	0.00427 J	ND (0.000035)	ND (0.00271)	ND (0.00073)	NR

Refer to footnotes at end of table.

Table 3.4.5-5 (Concluded)
Summary of SWMU 228A Site-Confirmatory Sampling RCRA Metals Analytical Results, September-December 1998
(Off-Site Laboratories)

Note: Values in **bold** exceed background soil concentrations.

^a EPA November 1986.

^b Analysis request/chain of custody record.

^c Estimated value; see data validation reports (Annex 3-F).

^d From Dinwiddie September 1997. The minimum background concentration between surface and subsurface values is used.

DU = Duplicate sample.

EB = Equipment blank.

EPA = U.S. Environmental Protection Agency.

ER = Environmental Restoration.

ft = Foot (feet).

GR = Grab sample.

ID = Identification.

J() = The reported value is greater than or equal to the method detection limit but is less than the practical quantitation limit, shown in parentheses.

mg/kg = Milligram(s) per kilogram.

mg/L = Milligram(s) per liter.

NA = Not applicable.

ND() = Not detected above the method detection limit, shown in parentheses.

NR = Not reported.

RCRA = Resource Conservation and Recovery Act.

S = Soil sample.

SWMU = Solid Waste Management Unit.

TJAOU = Tijeras Arroyo Operable Unit.

Table 3.4.5-6
Summary of SWMU 228A Soil Piles Confirmatory Sampling RCRA Metals Analytical Results, September–December 1998
(Off-Site Laboratories)

Sample Attributes				Metals (EPA Method 6010/7000) ^a (mg/kg)								
Record ^b Number	ER Sample ID (Figure 3.4.5-8)	Date Sampled	Sample Depth (ft)	Arsenic	Barium	Cadmium	Chromium	Lead	Mercury	Selenium	Silver	Uranium
600835	TJAOU-228A-GR-143-S	9/9/98	0-0.5	3.03	200	0.426 J (0.5)	10.1	17.3 ^c	0.0089 J (0.10)	0.108 J (0.5) ^c	ND (0.301)	7.2
600835	TJAOU-228A-GR-144-S	9/9/98	0-0.5	2.81	203	ND (0.275)	8.85	20.3 ^c	0.0084 J (0.10)	0.0960 J (0.5) ^c	ND (0.301)	14.8
600835	TJAOU-228A-GR-145-S	9/9/98	0-0.5	2.43	151	0.369 J (0.5)	9.60	9.93 ^c	0.0079 J (0.10)	0.104 J (0.5) ^c	ND (0.301)	20.3
600835	TJAOU-228A-GR-146-S	9/9/98	0-0.5	3.32	155	0.306 J (0.5)	9.57	8.87 ^c	ND (0.0078)	0.121 J (0.5) ^c	ND (0.301)	19.6
600835	TJAOU-228A-GR-147-S	9/9/98	0-0.5	2.28	131	0.711	10.2	32.4 ^c	0.0630 J (0.10)	ND (0.0891) ^c	ND (0.301)	21.9
600835	TJAOU-228A-GR-148-S	9/9/98	0-0.5	2.29	138	0.742	10.4	32.5 ^c	0.0569 J (0.10)	0.139 J (0.5) ^c	ND (0.301)	20.9
600835	TJAOU-228A-GR-149-S	9/9/98	0-0.5	1.76	158	0.518	9.90	7.50 ^c	ND (0.0078)	ND (0.0891) ^c	ND (0.301)	34.5
600835	TJAOU-228A-GR-150-S	9/9/98	0-0.5	2.01	140	0.706	11.8	8.67 ^c	ND (0.0078)	ND (0.0891) ^c	ND (0.301)	69.1
601212	TJAOU-228A-GR-219-S	12/3/98	0-0.5	2.42	109	ND (0.019)	6.16	7.26	ND (0.00225)	0.279 J (0.500)	ND (0.031)	NR
601212	TJAOU-228A-GR-221-S	12/3/98	0-0.5	2.35	105	ND (0.019)	5.79	8.64	ND (0.00225)	0.473 J (0.485)	0.0733 J (0.485)	NR
601212	TJAOU-228A-GR-221-DU	12/3/98	0-0.5	1.84	81.0	ND (0.019)	5.21	6.64	ND (0.00225)	0.365 J (0.495)	ND (0.031)	NR
601212	TJAOU-228A-GR-223-S	12/3/98	0-0.5	1.98	70.0	ND (0.019)	6.78	6.50	ND (0.00225)	0.275 J (0.490)	ND (0.031)	NR
601212	TJAOU-228A-GR-225-S	12/3/98	0-0.5	2.73	105	0.564	6.28	8.57	ND (0.00225)	0.451 J (0.485)	0.0591 J (0.485)	NR
601212	TJAOU-228A-GR-227-S	12/3/98	0-0.5	2.69	128	ND (0.019)	7.44	9.91	ND (0.00225)	0.662	0.129 J (0.485)	NR
Background Soil Concentrations—North Supergroup ^d				4.4	200	0.9	12.8	11.2	<0.1	<1	<1	2.3

Note: Values in **bold** exceed background soil concentrations.

^a EPA November 1986.

^b Analysis request/chain of custody record.

^c Estimated value; see data validation reports (Annex 3-F).

^d From Dinwiddie September 1997. The minimum background concentration between surface and subsurface values is used.

DU = Duplicate sample.

EPA = U.S. Environmental Protection Agency.

ER = Environmental Restoration.

ft = Foot (feet).

GR = Grab Sample.

ID = Identification.

J() = The reported value is greater than or equal to the method detection limit, but is less than the practical quantitation limit, shown in parentheses.

mg/kg = Milligram(s) per kilogram.

ND() = Not detected above the method detection limit, shown in parentheses.

NR = Not reported.

RCRA = Resource Conservation and Recovery Act.

S = Soil sample.

SWMU = Solid Waste Management Unit.

TJAOU = Tijeras Arroyo Operable Unit.

Table 3.4.5-7
HE Analytical Method Detection Limits (EPA Method 8330^a)
Used for SWMU 228A Confirmatory Sampling
September–December 1998
(Off-Site Laboratories)

Analyte	Soil Sample MDL (µg/kg)	Aqueous EB Sample MDL (µg/L)
4-amino-2,6-dinitrotoluene	5.5–79	0.02–0.16
2-amino-4,6-dinitrotoluene	6.6–17	0.019–0.14
1,3-dinitrobenzene	4.1–16	0.02–0.11
2,4-dinitrotoluene	6.2–17	0.014–0.10
2,6-dinitrotoluene	6.5–17	0.043–0.13
HMX	5.3–24	0.046–0.095
Nitrobenzene	5.2–9.0	0.016–0.12
2-nitrotoluene	7.8–41	0.024–0.16
3-nitrotoluene	11–30	0.031–0.39
4-nitrotoluene	11–31	0.034–0.19
RDX	9.7–31	0.018–0.12
Tetryl	7.5–94	0.022–0.18
1,3,5-trinitrobenzene	6.6–32	0.021–0.32
2,4,6-trinitrotoluene	5.7–19	0.029–0.11

^aEPA November 1986.

EB = Equipment blank.
EPA = U.S. Environmental Protection Agency.
HE = High explosive.
HMX = 1,3,5,7-tetranitro-1,3,5,7-tetrazacyclooctane.
MDL = Method detection limit.
RDX = 1,3,5-trinitro-1,3,5-triazacyclohexane.
µg/kg = Microgram(s) per kilogram.
µg/L = Microgram(s) per liter.
SWMU = Solid Waste Management Unit.
Tetryl = 2,4,6-trinitrophenylmethylnitramine.

Table 3.4.5-8
Summary of SWMU 228A Site-Confirmatory Sampling VOC Analytical Results^a
September–December 1998
(Off-Site Laboratories)

Record Number ^c	Sample Attributes			VOCs (EPA Method 8260 ^b) (µg/kg)	
	ER Sample ID (Figure 3.4.5-8)	Date Sampled	Sample Depth (ft)	Benzene	Methylene Chloride
600799	TJAOU-228A-GR-120-S	9/8/98	0–0.5	ND (0.98)	1.1 J (5)
600799	TJAOU-228A-GR-123-S	9/8/98	0–0.5	ND (0.98)	1.2 J (5)
600799	TJAOU-228A-GR-123-DU	9/8/98	0–0.5	ND (0.98)	1.0 J (5)
600799	TJAOU-228A-GR-129-S	9/8/98	0–0.5	ND (0.98)	1.3 J (5)
600835	TJAOU-228A-GR-133-S	9/8/98	0–0.5	1.2	ND (0.48)
600835	TJAOU-228A-GR-133-DU	9/8/98	0–0.5	ND (0.98)	ND (0.48)
600835	TJAOU-228A-GR-137-S	9/8/98	0–0.5	ND (0.98)	ND (0.48)
600835	TJAOU-228A-GR-140-S	9/8/98	0–0.5	ND (0.98)	ND (0.48)
601188	TJAOU-228A-GR-151-S	12/1/98	0–0.5	ND (0.25)	ND (0.25)
601188	TJAOU-228A-GR-156-S	12/1/98	0–0.5	ND (0.25)	ND (0.25)
601188	TJAOU-228A-GR-161-S	12/1/98	0–0.5	ND (0.25)	3.2 J (5.00) ^d
601188	TJAOU-228A-GR-161-DU	12/1/98	0–0.5	ND (0.25)	ND (0.25)
601189	TJAOU-228A-GR-166-S	12/1/98	0–0.5	ND (0.25)	ND (0.25)
601189	TJAOU-228A-GR-171-S	12/1/98	0–0.5	ND (0.25)	ND (0.25)
601189	TJAOU-228A-GR-171-DU	12/1/98	0–0.5	ND (0.25)	ND (0.25)
601190	TJAOU-228A-GR-176-S	12/2/98	0–0.5	ND (0.25)	ND (0.25)
601190	TJAOU-228A-GR-181-S	12/2/98	0–0.5	ND (0.25)	ND (0.25)
601190	TJAOU-228A-GR-181-DU	12/2/98	0–0.5	ND (0.25)	ND (0.25)
601190	TJAOU-228A-GR-186-S	12/2/98	0–0.5	ND (0.25)	ND (0.25)
601191	TJAOU-228A-GR-191-S	12/2/98	0–0.5	ND (0.25)	ND (0.25)
601191	TJAOU-228A-GR-191-DU	12/2/98	0–0.5	ND (0.25)	ND (0.25)
601191	TJAOU-228A-GR-196-S	12/2/98	0–0.5	ND (0.25)	ND (0.25)
601192	TJAOU-228A-GR-201-S	12/3/98	0–0.5	ND (0.25)	ND (0.25)
601192	TJAOU-228A-GR-201-DU	12/3/98	0–0.5	ND (0.25)	ND (0.25)
601192	TJAOU-228A-GR-206-S	12/3/98	0–0.5	ND (0.25)	ND (0.25)
601192	TJAOU-228A-GR-211-S	12/3/98	0–0.5	ND (0.25)	ND (0.25)
601192	TJAOU-228A-GR-211-DU	12/3/98	0–0.5	ND (0.25)	ND (0.25)
601212	TJAOU-228A-GR-216-S	12/3/98	2–3	ND (0.25)	7.2
Quality Assurance/Quality Control Samples (all in µg/L)					
600836	TJAOU-228A-GR-TB	9/8/98	NA	ND (0.98)	ND (0.48)
600836	TJAOU-228A-GR-EB	9/8/98	NA	ND (0.98)	ND (0.48)
601189	TJAOU-228A-EB	12/1/98	NA	ND (0.3)	1.5 J (5.00) ^d
601189	TJAOU-228A-TB	12/1/98	NA	ND (0.3)	3.4 J (5.00) ^d
601191	TJAOU-228A-EB	12/2/98	NA	ND (0.3)	ND (1.2)

Refer to footnotes at end of table.

Table 3.4.5-8 (Concluded)
Summary of SWMU 228A Site-Confirmatory Sampling VOC Analytical Results^a
September–December 1998
(Off-Site Laboratories)

Sample Attributes				VOCs (EPA Method 8260 ^b) (µg/kg)	
Record Number ^c	ER Sample ID (Figure 3.4.5-8)	Date Sampled	Sample Depth (ft)	Benzene	Methylene Chloride
601191	TJAOU-228A-TB	12/2/98	NA	ND (0.3)	1.6 J (5.00)
601212	TJAOU-228A-EB	12/3/98	NA	ND (0.3)	ND (1.2)
601212	TJAOU-228A-TB	12/3/98	NA	ND (0.3)	ND (1.2)

Note: Values in **bold** represent detected VOCs.

^a Detected VOCs only.

^b EPA November 1986.

^c Analysis request/chain of custody record.

^d Estimated value; see data validation reports (Annex 3-F).

DU = Duplicate sample.

EB = Equipment blank.

EPA = U.S. Environmental Protection Agency.

ER = Environmental Restoration.

ft = Foot (feet).

GR = Grab Sample.

ID = Identification.

J() = The reported value is greater than or equal to the method detection limit but is less than the practical quantitation limit, shown in parentheses.

µg/kg = Microgram(s) per kilogram.

µg/L = Microgram(s) per liter.

NA = Not applicable.

ND() = Not detected above the method detection limit, shown in parentheses.

S = Soil sample.

SWMU = Solid Waste Management Unit.

TB = Trip blank.

TJAOU = Tijeras Arroyo Operable Unit.

VOC = Volatile organic compound.

Table 3.4.5-9
Summary of SWMU 228A Soil Piles Confirmatory Sampling VOC Analytical Results^a
September–December 1998
(Off-Site Laboratories)

Record Number ^c	Sample Attributes			VOCs (EPA Method 8260 ^b) (µg/kg)	
	ER Sample ID (Figure 3.4.5-8)	Date Sampled	Sample Depth (ft)	Benzene	Methylene Chloride
600835	TJAOU-228A-GR-143-S	9/8/98	0–0.5	ND (0.98)	ND (0.48)
600835	TJAOU-228A-GR-145-S	9/8/98	0–0.5	ND (0.98)	ND (0.48)
600835	TJAOU-228A-GR-147-S	9/8/98	0–0.5	ND (0.98)	ND (0.48)
600835	TJAOU-228A-GR-149-S	9/8/98	0–0.5	ND (0.98)	ND (0.48)
601212	TJAOU-228A-GR-221-S	12/3/98	0–0.5	ND (0.25)	1.5 J (5.00)
601212	TJAOU-228A-GR-221-DU	12/3/98	0–0.5	ND (0.25)	ND (0.25)
601212	TJAOU-228A-GR-226-S	12/3/98	0–0.5	ND (0.25)	ND (0.25)

Note: Values in **bold** represent detected VOCs.

^a Detected VOCs only.

^b EPA November 1986.

^c Analysis request/chain of custody record.

DU = Duplicate sample.

EPA = U.S. Environmental Protection Agency.

ER = Environmental Restoration.

ft = Foot (feet).

GR = Grab Sample.

ID = Identification.

J() = The reported value is greater than or equal to the method detection limit but is less than the practical quantitation limit, shown in parentheses.

µg/kg = Microgram(s) per kilogram.

ND () = Not detected above the method detection limit, shown in parentheses.

S = Soil sample.

SWMU = Solid Waste Management Unit.

TJAOU = Tijeras Arroyo Operable Unit.

VOC = Volatile organic compound.

Table 3.4.5-10
VOC Analytical Method Detection Limits (EPA Method 8260^a) Used for SWMU 228A
Confirmatory Sampling, September–December 1998
(Off-Site Laboratories)

Analyte	Soil Sample MDL ($\mu\text{g/kg}$)	Aqueous EB and TB Sample MDL ($\mu\text{g/L}$)
Acetone	2.2	3.7
Benzene	0.25–0.98	0.3–0.98
Bromobenzene	0.94	0.94
Bromochloromethane	0.67	0.67
Bromodichloromethane	0.24–0.80	0.4–0.80
Bromoform	0.27–0.48	0.4–0.48
2-butanone	2.1	5.9
n-butylbenzene	2.1	2.1
sec-butylbenzene	2.0	2.0
tert-butylbenzene	1.8	1.8
Carbon disulfide	2.2	1.8
Carbon tetrachloride	0.22–1.9	0.2–1.9
Chlorobenzene	0.25–1.1	0.3–1.1
Chloroethane	0.72–1.6	0.3–1.6
Chloroform	0.24–1.1	0.7–1.1
2-chlorotoluene	2.1	2.1
4-chlorotoluene	1.6	1.6
1,2-dibromo-3-chloropropane	0.96	0.96
Dibromochloromethane	0.21–0.59	0.3–0.59
1,2-dibromoethane	0.46	0.46
Dibromomethane	5.0	5.0
1,2-dichlorobenzene	0.85	0.85
1,3-dichlorobenzene	1.1	1.1
1,4-dichlorobenzene	1.0	1.0
Dichlorodifluoromethane	1.8	1.8
1,1-dichloroethane	0.2–1.2	0.4–1.2
1,2-dichloroethane	0.23–0.46	0.2–0.46
1,1-dichloroethene	0.25–2.1	0.7–2.1
cis-1,2-dichloroethene	0.25–1.2	0.7–1.2
trans-1,2-dichloroethene	0.19–1.6	0.3–1.6
1,2-dichloropropane	0.23–0.81	0.2–0.81
1,3-dichloropropane	0.44	0.44
2,2-dichloropropane	3.4	3.4
1,1-dichloropropene	2.0	2.0
cis-1,3-dichloropropene	0.25	0.3
trans-1,3-dichloropropene	0.22	0.3
Ethyl benzene	0.23–1.6	0.3–1.6
Hexachlorobutadiene	1.8	1.8
2-hexanone	4.4	3.2
Isopropylbenzene	1.7	1.7
4-isopropyltoluene	1.8	1.8
Methyl bromide	0.67–1.0	0.4–1.0
Methyl chloride	0.43–1.9	0.2–1.9
Methylene chloride	0.25–0.48	0.48–1.2

Refer to footnotes at end of table.

Table 3.4.5-10 (Concluded)
VOC Analytical Method Detection Limits (EPA Method 8260^a) Used for SWMU 228A
Confirmatory Sampling, September–December 1998
(Off-Site Laboratories)

Analyte	Soil Sample MDL (µg/kg)	Aqueous EB and TB Sample MDL (µg/L)
Naphthalene	0.61	0.61
4-methyl-2-pentanone	2.9	1.6
n-propylbenzene	1.8	1.8
Styrene	0.22–2.1	0.2–2.1
1,1,1,2-tetrachloroethane	0.90	0.90
1,1,2,2-tetrachloroethane	0.46–0.96	0.5–0.96
Tetrachloroethene	0.23–1.6	0.7–1.6
Toluene	0.22–1.5	0.5–1.5
1,2,3-trichlorobenzene	1.0	1.0
1,2,4-trichlorobenzene	0.90	0.90
1,1,1-trichloroethane	0.18–1.7	0.2–1.7
1,1,2-trichloroethane	0.24–0.62	0.4–0.62
Trichloroethene	0.27–1.2	0.6–1.2
Trichlorofluoromethane	5.0	5.0
1,2,3-trichloropropane	0.46	0.46
1,2,4-trimethylbenzene	1.5	1.5
1,3,5-trimethylbenzene	1.6	1.6
Vinyl acetate	1.8	1.8
Vinyl chloride	0.4–1.8	0.4–1.8
Xylenes	0.62–3.1	1.1–3.1

^aEPA November 1986.

EB = Equipment blank.

EPA = U.S. Environmental Protection Agency.

MDL = Method detection limit.

µg/kg = Microgram(s) per kilogram.

µg/L = Microgram(s) per liter.

SWMU = Solid Waste Management Unit.

TB = Trip blank.

VOC = Volatile organic compound.

Table 3.4.5-11
Summary of SWMU 228A Site-Confirmatory Sampling SVOC Analytical Results^a
September-December 1998
(Off-Site Laboratories)

Sample Attributes			SVOCs (EPA Method 8270) (µg/kg)					
Record ^c Number	ER Sample ID (Figure 3.4.5-8)	Date Sampled	Sample Depth (ft)	Acenaphthene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene
600799	TJAOU-228A-GR-120-S	9/8/98	0-0.5	ND (20)	ND (20)	ND (20)	ND (20)	ND (30)
600799	TJAOU-228A-GR-123-S	9/8/98	0-0.5	ND (20)	ND (20)	40 J (330)	ND (20)	ND (30)
600799	TJAOU-228A-GR-123-DU	9/8/98	0-0.5	ND (20)	ND (20)	140 J (330)	110 J (330)	140 J (330)
600799	TJAOU-228A-GR-129-S	9/8/98	0-0.5	70 J (330)	90 J (330)	200 J (330)	190 J (330)	140 J (330)
600835	TJAOU-228A-GR-133-S	9/8/98	0-0.5	ND (20)	30 J (330)	320 J (330)	250 J (330)	330
600835	TJAOU-228A-GR-133-DU	9/8/98	0-0.5	ND (20)	110 J (330)	190 J (330)	180 J (330)	250 J (330)
600835	TJAOU-228A-GR-137-S	9/8/98	0-0.5	ND (20)	ND (20)	ND (10)	ND (10)	ND (20)
600835	TJAOU-228A-GR-140-S	9/8/98	0-0.5	ND (20)	90 J (330)	250 J (330)	260 J (330)	370
601188	TJAOU-228A-GR-151-S	12/1/98	0-0.5	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
601188	TJAOU-228A-GR-156-S	12/1/98	0-0.5	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
601188	TJAOU-228A-GR-161-S	12/1/98	0-0.5	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
601188	TJAOU-228A-GR-161-DU	12/1/98	0-0.5	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
601189	TJAOU-228A-GR-166-S	12/1/98	0-0.5	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
601189	TJAOU-228A-GR-171-S	12/1/98	0-0.5	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
601189	TJAOU-228A-GR-171-DU	12/1/98	0-0.5	ND (10)	95 J (333)	270 J (333)	180 J (333)	360
601190	TJAOU-228A-GR-176-S	12/2/98	0-0.5	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
601190	TJAOU-228A-GR-181-S	12/2/98	0-0.5	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
601190	TJAOU-228A-GR-181-DU	12/2/98	0-0.5	ND (10)	ND (10)	ND (10)	ND (10)	250 J (333)
601190	TJAOU-228A-GR-186-S	12/2/98	0-0.5	ND (10)	ND (10)	200 J (333)	ND (10)	ND (10)
601191	TJAOU-228A-GR-191-S	12/2/98	0-0.5	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
601191	TJAOU-228A-GR-191-DU	12/2/98	0-0.5	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
601191	TJAOU-228A-GR-196-S	12/2/98	0-0.5	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
601192	TJAOU-228A-GR-201-S	12/3/98	0-0.5	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
601192	TJAOU-228A-GR-201-DU	12/3/98	0-0.5	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
601192	TJAOU-228A-GR-206-S	12/3/98	0-0.5	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
601192	TJAOU-228A-GR-211-S	12/3/98	0-0.5	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
601192	TJAOU-228A-GR-211-DU	12/3/98	0-0.5	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
601212	TJAOU-228A-GR-216-S	12/3/98	2-3	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
Quality Assurance/Quality Control Samples (all in µg/L)								
600836	TJAOU-228A-GR-EB	9/8/98	NA	ND (0.6)	ND (0.6)	ND (0.5)	ND (0.7)	ND (0.9)
600836	TJAOU-228A-GR-EB	9/9/98	NA	ND (0.6)	ND (0.6)	ND (0.5)	ND (0.7)	ND (0.9)
601189	TJAOU-228A-EB	12/1/98	NA	ND (2.2)	ND (2.3)	ND (2.8)	ND (2)	ND (4.7)
601191	TJAOU-228A-EB	12/2/98	NA	ND (2.2)	ND (2.3)	ND (2.8)	ND (2)	ND (4.7)
601212	TJAOU-228A-EB	12/3/98	NA	ND (2.2)	ND (2.3)	ND (2.8)	ND (2)	ND (4.7)

Refer to footnotes at end of table.

Table 3.4.5-11 (Continued)
 Summary of SWMU 228A Site-Confirmatory Sampling SVOC Analytical Results^a
 September–December 1998
 (Off-Site Laboratories)

Sample Attributes				SVOCs (EPA Method 8270) ^b (µg/kg)				
Record ^c Number	ER Sample ID (Figure 3.4.5-8)	Date Sampled	Sample Depth (ft)	Benzo(ghi)perylene	Benzo(k)fluoranthene	Chrysene	Di-n-butyl phthalate	Bis(2-ethylhexyl)phthalate
600799	TJAOU-228A-GR-120-S	9/8/98	0-0.5	ND (53)	ND (30)	ND (20)	60 J (330)	50 J (330)
600799	TJAOU-228A-GR-123-S	9/8/98	0-0.5	ND (53)	ND (30)	170 J (330)	50 J (330)	40 J (330)
600799	TJAOU-228A-GR-123-DU	9/8/98	0-0.5	ND (53)	ND (30)	40 J (330)	ND (20)	70 J (330)
600799	TJAOU-228A-GR-129-S	9/8/98	0-0.5	ND (53)	ND (30)	220 J (330)	40 J (330)	ND (20)
600835	TJAOU-228A-GR-133-S	9/8/98	0-0.5	240 J (330)	280 J (330)	370	ND (10)	33 J (330)
600835	TJAOU-228A-GR-133-DU	9/8/98	0-0.5	180 J (330)	150 J (330)	220 J (330)	ND (10)	48 J (330)
600835	TJAOU-228A-GR-137-S	9/8/98	0-0.5	ND (49)	ND (30)	ND (10)	ND (10)	33 J (330)
600835	TJAOU-228A-GR-140-S	9/8/98	0-0.5	250 J (330)	230 J (330)	280 J (330)	ND (10)	34 J (330)
601188	TJAOU-228A-GR-151-S	12/1/98	0-0.5	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
601188	TJAOU-228A-GR-156-S	12/1/98	0-0.5	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
601188	TJAOU-228A-GR-161-S	12/1/98	0-0.5	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
601188	TJAOU-228A-GR-161-DU	12/1/98	0-0.5	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
601189	TJAOU-228A-GR-166-S	12/1/98	0-0.5	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
601189	TJAOU-228A-GR-171-S	12/1/98	0-0.5	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
601189	TJAOU-228A-GR-171-DU	12/1/98	0-0.5	130 J (333)	ND (10)	300 J (333)	ND (10)	ND (10)
601190	TJAOU-228A-GR-176-S	12/2/98	0-0.5	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
601190	TJAOU-228A-GR-181-S	12/2/98	0-0.5	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
601190	TJAOU-228A-GR-181-DU	12/2/98	0-0.5	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
601190	TJAOU-228A-GR-186-S	12/2/98	0-0.5	ND (10)	ND (10)	230 J (333)	ND (10)	ND (10)
601191	TJAOU-228A-GR-191-S	12/2/98	0-0.5	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
601191	TJAOU-228A-GR-191-DU	12/2/98	0-0.5	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
601191	TJAOU-228A-GR-196-S	12/2/98	0-0.5	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
601192	TJAOU-228A-GR-201-S	12/3/98	0-0.5	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
601192	TJAOU-228A-GR-201-DU	12/3/98	0-0.5	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
601192	TJAOU-228A-GR-206-S	12/3/98	0-0.5	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
601192	TJAOU-228A-GR-211-S	12/3/98	0-0.5	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
601192	TJAOU-228A-GR-211-DU	12/3/98	0-0.5	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
601212	TJAOU-228A-GR-216-S	12/3/98	2-3	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
Quality Assurance/Quality Control Samples (all in µg/L)								
600836	TJAOU-228A-GR-EB	9/8/98	NA	ND (1.6)	ND (0.8)	ND (0.5)	ND (0.5)	ND (0.6)
600836	TJAOU-228A-GR-EB	9/9/98	NA	ND (1.6)	ND (0.8)	ND (0.5)	ND (0.5)	ND (0.6)
601189	TJAOU-228A-EB	12/1/98	NA	ND (2.5)	ND (2.6)	ND (2.2)	ND (2.9)	ND (3.7)
601191	TJAOU-228A-EB	12/2/98	NA	ND (2.5)	ND (2.6)	ND (2.2)	ND (2.9)	ND (3.7)
601212	TJAOU-228A-EB	12/3/98	NA	ND (2.5)	ND (2.6)	ND (2.2)	ND (2.9)	ND (3.7)

Refer to footnotes at end of table.

Table 3.4.5-11 (Continued)
 Summary of SWMU 228A Site-Confirmatory Sampling SVOC Analytical Results^a
 September–December 1998
 (Off-Site Laboratories)

Sample Attributes				SVOCs (EPA Method 8270) (µg/kg)				
Record Number	ER Sample ID (Figure 3.4.5-8)	Date Sampled	Sample Depth (ft)	Fluoranthene	Fluorene	Indeno(1,2,3-cd)pyrene	Phenanthrene	Pyrene
600799	TJAOU-228A-GR-120-S	9/8/98	0-0.5	ND (20)	ND (20)	ND (57)	ND (20)	40 J (330)
600799	TJAOU-228A-GR-123-S	9/8/98	0-0.5	70 J (330)	ND (20)	ND (56)	40 J (330)	80 J (330)
600799	TJAOU-228A-GR-123-DU	9/8/98	0-0.5	280 J (330)	ND (20)	ND (56)	110 J (330)	320 J (330)
600799	TJAOU-228A-GR-129-S	9/8/98	0-0.5	460	50 J (330)	ND (56)	420	560
600835	TJAOU-228A-GR-133-S	9/8/98	0-0.5	330 J (330)	ND (10)	ND (10)	35 J (330)	600
600835	TJAOU-228A-GR-133-DU	9/8/98	0-0.5	320 J (330)	ND (10)	41 J (330)	110 J (330)	390
600835	TJAOU-228A-GR-137-S	9/8/98	0-0.5	ND (10)	ND (10)	ND (10)	ND (20)	ND (33)
600835	TJAOU-228A-GR-140-S	9/8/98	0-0.5	380	ND (10)	40 J (330)	94 J (330)	360
601188	TJAOU-228A-GR-151-S	12/1/98	0-0.5	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
601188	TJAOU-228A-GR-156-S	12/1/98	0-0.5	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
601188	TJAOU-228A-GR-161-S	12/1/98	0-0.5	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
601188	TJAOU-228A-GR-161-DU	12/1/98	0-0.5	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
601189	TJAOU-228A-GR-166-S	12/1/98	0-0.5	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
601189	TJAOU-228A-GR-171-S	12/1/98	0-0.5	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
601189	TJAOU-228A-GR-171-DU	12/1/98	0-0.5	630	ND (10)	99 J (333)	420	490
601190	TJAOU-228A-GR-176-S	12/2/98	0-0.5	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
601190	TJAOU-228A-GR-181-S	12/2/98	0-0.5	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
601190	TJAOU-228A-GR-181-DU	12/2/98	0-0.5	190 J (333)	ND (10)	ND (10)	ND (10)	ND (10)
601190	TJAOU-228A-GR-186-S	12/2/98	0-0.5	420	ND (10)	ND (10)	ND (10)	320 J (333)
601191	TJAOU-228A-GR-191-S	12/2/98	0-0.5	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
601191	TJAOU-228A-GR-191-DU	12/2/98	0-0.5	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
601191	TJAOU-228A-GR-196-S	12/2/98	0-0.5	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
601192	TJAOU-228A-GR-201-S	12/3/98	0-0.5	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
601192	TJAOU-228A-GR-201-DU	12/3/98	0-0.5	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
601192	TJAOU-228A-GR-206-S	12/3/98	0-0.5	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
601192	TJAOU-228A-GR-211-S	12/3/98	0-0.5	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
601192	TJAOU-228A-GR-211-DU	12/3/98	0-0.5	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
601212	TJAOU-228A-GR-216-S	12/3/98	2-3	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
Quality Assurance/Quality Control Samples (all in µg/L)								
600836	TJAOU-228A-GR-EB	9/8/98	NA	ND (0.6)	ND (0.7)	ND (1.7)	ND (0.6)	ND (0.6)
600836	TJAOU-228A-GR-EB	9/9/98	NA	ND (0.6)	ND (0.7)	ND (1.7)	ND (0.6)	ND (0.6)
601189	TJAOU-228A-EB	12/1/98	NA	ND (3.1)	ND (2.1)	ND (3.4)	ND (1.8)	ND (2.5)
601191	TJAOU-228A-EB	12/2/98	NA	ND (3.1)	ND (2.1)	ND (3.4)	ND (1.8)	ND (2.5)
601212	TJAOU-228A-EB	12/3/98	NA	ND (3.1)	ND (2.1)	ND (3.4)	ND (1.8)	ND (2.5)

Refer to footnotes at end of table.

Table 3.4.5-11 (Concluded)
Summary of SWMU 228A Site-Confirmatory Sampling SVOC Analytical Results^a
September-December 1998
(Off-Site Laboratories)

Note: Values in **bold** represent detected SVOCs.

^a Detected SVOCs only.

^b EPA November 1986.

^c Analysis request/chain of custody record.

DU = Duplicate sample.
EB = Equipment blank.
EPA = U.S. Environmental Protection Agency.
ER = Environmental Restoration.
GR = Grab sample.
ft = Foot (feet).
ID = Identification.
J () = The reported value is greater than or equal to the method detection limit, but is less than the practical quantitation limit, shown in parentheses.
µg/kg = Microgram(s) per kilogram.
µg/L = Microgram(s) per liter.
NA = Not applicable.
ND () = Not detected above the method detection limit, shown in parentheses.
S = Soil sample.
SVOC = Semivolatile organic compound.
SWMU = Solid Waste Management Unit.
TJAOU = Tijeras Arroyo Operable Unit.

Table 3.4.5-12
Summary of SWMU 228A Soil Piles Confirmatory Sampling SVOC Analytical Results^a
September–December 1998
(Off-Site Laboratories)

Sample Attributes			SVOCs (EPA Method 8270 ^b) (µg/kg)					
Record Number ^c	ER Sample ID (Figure 3.4.5-8)	Date Sampled	Sample Depth (ft)	Acenaphthene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene
600835	TJAOU-228A-GR-143-S	9/8/98	0–0.5	ND (20)	ND (20)	ND (10)	ND (10)	ND (20)
600835	TJAOU-228A-GR-145-S	9/8/98	0–0.5	ND (20)	ND (20)	80 J (330)	70 J (330)	90 J (330)
600835	TJAOU-228A-GR-147-S	9/8/98	0–0.5	ND (20)	30 J (330)	70 J (330)	80 J (330)	ND (20)
600835	TJAOU-228A-GR-149-S	9/8/98	0–0.5	ND (20)	ND (20)	40 J (330)	40 J (330)	40 J (330)
601212	TJAOU-228A-GR-221-S	12/3/98	0–0.5	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
601212	TJAOU-228A-GR-221-DU	12/3/98	0–0.5	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
601212	TJAOU-228A-GR-226-S	12/3/98	0–0.5	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)

Sample Attributes			SVOCs (EPA Method 8270 ^b) (µg/kg)					
Record Number ^c	ER Sample ID (Figure 3.4.5-8)	Date Sampled	Sample Depth (ft)	Benzo(ghi)perylene	Benzo(k)fluoranthene	Chrysene	Di-n-butyl phthalate	Bis(2-ethylhexyl) phthalate
600835	TJAOU-228A-GR-143-S	9/8/98	0–0.5	ND (49)	ND (30)	ND (10)	ND (10)	75 J (330)
600835	TJAOU-228A-GR-145-S	9/8/98	0–0.5	ND (50)	ND (30)	100 J (330)	ND (10)	38 J (330)
600835	TJAOU-228A-GR-147-S	9/8/98	0–0.5	50 J (330)	ND (30)	90 J (330)	40 J (330)	110 J (330)
600835	TJAOU-228A-GR-149-S	9/8/98	0–0.5	ND (49)	40 J (330)	50 J (330)	ND (10)	73 J (330)
601212	TJAOU-228A-GR-221-S	12/3/98	0–0.5	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
601212	TJAOU-228A-GR-221-DU	12/3/98	0–0.5	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)
601212	TJAOU-228A-GR-226-S	12/3/98	0–0.5	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)

Refer to footnotes at end of table.

Table 3.4.5-12 (Concluded)
Summary of SWMU 228A Soil Piles Confirmatory Sampling SVOC Analytical Results^a
September-December 1998
(Off-Site Laboratories)

Sample Attributes				SVOCs (EPA Method 8270 ^b) (µg/kg)					
Record Number ^c	ER Sample ID (Figure 3.4.5-8)	Date Sampled	Sample Depth (ft)	Fluoranthene	Fluorene	Indeno(1,2,3-cd)pyrene	Phenanthrene	Pyrene	
600835	TJAOU-228A-GR-143-S	9/8/98	0-0.5	ND (10)	ND (10)	ND (10)	ND (20)	ND (33)	
600835	TJAOU-228A-GR-145-S	9/8/98	0-0.5	170 J (330)	ND (10)	ND (10)	70 J (330)	140 J (330)	
600835	TJAOU-228A-GR-147-S	9/8/98	0-0.5	180 J (330)	ND (10)	50 J (330)	160 J (330)	160 J (330)	
600835	TJAOU-228A-GR-149-S	9/8/98	0-0.5	80 J (330)	ND (10)	ND (10)	60 J (330)	75 J (330)	
601212	TJAOU-228A-GR-221-S	12/3/98	0-0.5	170 J (333)	ND (10)	ND (10)	ND (10)	ND (10)	
601212	TJAOU-228A-GR-221-DU	12/3/98	0-0.5	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)	
601212	TJAOU-228A-GR-226-S	12/3/98	0-0.5	ND (10)	ND (10)	ND (10)	ND (10)	ND (10)	

Note: Values in **bold** represent detected SVOCs.

^a Detected SVOCs only.

^b EPA November 1986.

^c Analysis request/chain of custody record.

DU = Duplicate sample.

EPA = U.S. Environmental Protection Agency.

ER = Environmental Restoration.

ft = Foot (feet).

GR = Grab sample.

ID = Identification.

J() = The reported value is greater than or equal to the method detection limit but is less than the practical quantitation limit, shown in parentheses.

µg/kg = Microgram(s) per kilogram.

ND() = Not detected above the method detection limit, shown in parentheses.

S = Soil sample.

SVOC = Semivolatile organic compound.

SWMU = Solid Waste Management Unit.

TJAOU = Tijeras Arroyo Operable Unit.

Table 3.4.5-13
SVOC Analytical Method Detection Limits
(EPA Method 8270^a) Used for SWMU 228A Confirmatory Sampling
September–December 1998
(Off-Site Laboratories)

Analyte	Soil Sample MDL (µg/kg)	Aqueous EB Sample MDL (µg/L)
Acenaphthene	10–20	0.6–2.2
Acenaphthylene	10–20	0.5–1.3
Anthracene	10–20	0.6–2.3
Benzidine	10–1700	0.4
Benzo(a)anthracene	10–20	0.5–2.8
Benzo(a)pyrene	10–20	0.7–2
Benzo(b)fluoranthene	10–30	0.9–4.7
Benzo(ghi)perylene	10–53	1.7–2.5
Benzo(k)fluoranthene	10–30	0.8–2.6
Benzoic acid	20–1700	0.5–9.3
Benzyl alcohol	10–93	0.6–2.5
4-bromophenyl phenyl ether	10–30	0.03–0.6
Butylbenzyl phthalate	10–20	0.5–3.7
4-chloro-3-methylphenol	10–30	0.5–3.1
4-chlorobenzenamine	20–66	0.5–1.5
bis(2-chloroethoxy)methane	10–20	0.3–2.5
bis(2-chloroethyl)ether	10–20	0.6–2
bis-chloroisopropyl ether	10	0.61
2-chloronaphthalene	10–20	0.7–2.4
2-chlorophenol	10–20	0.4–2.1
4-chlorophenyl phenyl ether	10–20	0.6–2.8
Chrysene	10–20	0.5–2.2
m,p-cresol	10	1.8
o-cresol	10–33	0.5–2.1
Di-n-butyl phthalate	10–20	0.5–2.9
Di-n-octyl phthalate	10–46	0.6–4.2
Dibenzo[a,h]anthracene	10–60	1.9–2.2
Dibenzofuran	7–20	0.5–4.3
1,2-dichlorobenzene	10–33	0.5–2.7
1,3-dichlorobenzene	10–20	0.5–2.5
1,4-dichlorobenzene	10–43	0.6–2.3
3,3-dichlorobenzidine	20	0.7–4.2
2,2-dichlorodisopropyl ether	20–53	0.6
2,4-dichlorophenol	10–110	0.3–1.4
Diethylphthalate	10–20	0.7–2.1
2,4-dimethylphenol	10–30	0.5–6.1
Dimethylphthalate	10–20	0.5–2.1
Dinitro-o-cresol	10–110	0.67–0.8
2,4-dinitrophenol	20–260	1.1–7.9

Refer to footnotes at end of table.

Table 3.4.5-13 (Concluded)
SVOC Analytical Method Detection Limits
(EPA Method 8270^a) Used for SWMU 228A Confirmatory Sampling
September–December 1998
(Off-Site Laboratories)

Analyte	Soil Sample MDL (µg/kg)	Aqueous EB Sample MDL (µg/L)
2,4-dinitrotoluene	10–20	0.7–1.4
2,6-dinitrotoluene	10–20	0.6–1.1
1,2-diphenylhydrazine	10	2.3
bis(2-ethylhexyl)phthalate	10–33	0.6–3.7
Fluoranthene	10–20	0.6–3.1
Fluorene	10–20	0.7–2.1
Hexachlorobenzene	10–30	0.5–2.9
Hexachlorobutadiene	10–30	0.5–3.8
Hexachlorocyclopentadiene	10–190	2.1–4.4
Hexachloroethane	10–36	0.8–3.4
Indeno(1,2,3-c,d)pyrene	10–57	1.8–3.4
Isophorone	10–30	0.5–2.6
2-methylnaphthalene	10–33	0.5–3.2
4-methylphenol	20–99	0.6
Naphthalene	10–20	0.5–2
Nitro-benzene	10–33	0.5–3.3
2-nitroaniline	10–20	0.6–2.8
3-nitroaniline	10–30	0.6–1.8
4-nitroaniline	10–53	0.6–1
2-nitrophenol	10–33	0.5–2.9
4-nitrophenol	10–69	0.6–3.5
n-nitrosodiphenylamine	10–20	0.6–5
n-nitrosodipropylamine	10–30	0.7–5
Pentachlorophenol	20–120	2.4–2.8
Phenanthrene	10–20	0.6–1.8
Phenol	10–43	0.5–0.8
Pyrene	10–33	0.6–2.5
1,2,4-trichlorobenzene	10–20	0.5–2.4
2,4,5-trichlorophenol	10–30	0.8–2.5
2,4,6-trichlorophenol	10–76	0.6–0.96

^aEPA November 1986.

EB = Equipment blank.

EPA = United State Environmental Protection Agency.

MDL = Method detection limit.

µg/kg = Microgram(s) per kilogram.

µg/L = Microgram(s) per liter.

SVOC = Semivolatile organic compound.

SWMU = Solid Waste Management Unit.

Table 3.4.5-14
Summary of SWMU 228A Site-Confirmatory Sampling Gamma Spectroscopy Analytical Results, September 1998–February 1999
(Off-Site Laboratories, except where indicated)

Record Number ^a	Sample Attributes			Activity (pCi/g)											
	ER Sample ID (Figure 3.4.5-8)	Date Sampled	Sample Depth (ft)	Uranium-235 ^b		Uranium-238 ^b		Thorium-232 ^b		Cesium-137 ^b					
				Result	Error	Result	Error	Result	Error	Result	Error	Result	Error	Result	Error
600799	TJAOU-228A-GR-120-S	9/8/98	0-0.5	0.3	0.2	5.1	7.2	NR	--	0.1	--	0.0	--		
600800	TJAOU-228A-GR-120-S (on-site laboratory)	9/8/98	0-0.5	0.202	0.194	0.987	0.558	0.846	0.402	ND (0.0292)					
600799	TJAOU-228A-GR-121-S	9/8/98	0-0.5	0.6	0.2	4.8	3.1	NR	--	0.2	--	0.1	--		
600799	TJAOU-228A-GR-122-S	9/8/98	0-0.5	0.4	0.2	2.6	5.3	NR	--	0.0	--	0.0	--		
600799	TJAOU-228A-GR-123-S	9/8/98	0-0.5	0.6	0.2	11.4	3.6	NR	--	0.3	--	0.2	--		
600800	TJAOU-228A-GR-123-S (on-site laboratory)	9/8/98	0-0.5	ND (0.215)	--	0.884	0.542	0.963	0.448	0.0124		0.00883			
600799	TJAOU-228A-GR-123-DU	9/8/98	0-0.5	0.4	0.2	2.2	3.4	NR	--	0.1	--	0.0	--		
600800	TJAOU-228A-GR-123-DU (on-site laboratory)	9/8/98	0-0.5	0.0909	0.0890	0.596	0.398	0.875	1.38	0.00764		0.00719			
600799	TJAOU-228A-GR-124-S	9/8/98	0-0.5	0.6	0.2	4.2	2.7	NR	--	0.1	--	0.4	--		
600799	TJAOU-228A-GR-125-S	9/8/98	0-0.5	0.2	0.1	1.6	2.0	NR	--	0.2	--	0.1	--		
600799	TJAOU-228A-GR-126-S	9/8/98	0-0.5	0.5	0.2	7.0	2.4	NR	--	0.4	--	0.3	--		
600799	TJAOU-228A-GR-127-S	9/8/98	0-0.5	0.1	0.2	1.1	6.9	NR	--	0.4	--	0.2	--		
600799	TJAOU-228A-GR-128-S	9/8/98	0-0.5	0.4	0.1	7.3	3.0	NR	--	0.0	--	0.1	--		
600799	TJAOU-228A-GR-129-S	9/8/98	0-0.5	0.2	0.1	6.0	2.8	NR	--	0.3	--	0.1	--		
600800	TJAOU-228A-GR-129-S (on-site laboratory)	9/8/98	0-0.5	0.131	0.194	4.37	0.912	ND (0.127)	--	0.0500		0.0293			
600799	TJAOU-228A-GR-130-S	9/8/98	0-0.5	0.4	0.2	6.6	2.4	NR	--	0.0	--	0.0	--		
600799	TJAOU-228A-GR-131-S	9/8/98	0-0.5	0.2	0.1	2.4	3.1	NR	--	0.1	--	0.0	--		
600799	TJAOU-228A-GR-132-S	9/8/98	0-0.5	0.3	0.2	4.3	1.5	NR	--	0.2	--	0.2	--		
600800	TJAOU-228A-GR-133-S (on-site laboratory)	9/8/98	0-0.5	ND (0.215)	--	0.584	0.424	0.780	0.372	ND (0.0291)		--			
600835	TJAOU-228A-GR-133-S	9/8/98	0-0.5	0.8	0.3	8.0	4.6	NR	--	0.4	--	0.3	--		
600800	TJAOU-228A-GR-133-DU (on-site laboratory)	9/8/98	0-0.5	ND (0.238)	--	0.808	0.604	0.970	0.477	ND (0.0325)		--			
600835	TJAOU-228A-GR-133-DU	9/8/98	0-0.5	0.2	0.3	5.4	6.0	NR	--	0.3	--	0.2	--		
600835	TJAOU-228A-GR-134-S	9/8/98	0-0.5	0.3	0.3	5.0	2.9	NR	--	0.3	--	0.1	--		
600835	TJAOU-228A-GR-135-S	9/8/98	0-0.5	0.3	0.1	4.7	3.6	NR	--	0.2	--	0.1	--		
600835	TJAOU-228A-GR-136-S	9/8/98	0-0.5	0.4	0.2	6.4	5.6	NR	--	0.4	--	0.1	--		
600800	TJAOU-228A-GR-137-S (on-site laboratory)	9/8/98	0-0.5	ND (0.216)	--	0.941	0.413	1.21	0.616	ND (0.0342)		--			
600835	TJAOU-228A-GR-137-S	9/8/98	0-0.5	0.3	0.2	8.2	4.7	NR	--	0.2	--	0.1	--		

Refer to footnotes at end of table.

Table 3.4.5-14 (Continued)
Summary of SWMU 228A Site-Confirmatory Sampling Gamma Spectroscopy Analytical Results, September 1998–February 1999
(Off-Site Laboratories, except where indicated)

Record Number ^a	Sample Attributes			Activity (pCi/g)											
	ER Sample ID (Figure 3.4.5-8)	Date Sampled	Sample Depth (ft)	Uranium-235		Uranium-238		Thorium-232		Cesium-137					
				Result	Error ^b	Result	Error ^b	Result	Error ^b	Result	Error ^b	Result	Error ^b	Result	Error ^b
600835	TJAOU-228A-GR-138-S	9/8/98	0-0.5	0.7	0.2	6.6	1.9	NR	--	0.0	0.0	0.0	0.0		
600835	TJAOU-228A-GR-139-S	9/8/98	0-0.5	0.2	0.1	5.6	4.7	NR	--	0.3	0.1				
600835	TJAOU-228A-GR-140-S	9/8/98	0-0.5	0.4	0.1	5.4	1.9	NR	--	0.2	0.2				
600800	TJAOU-228A-GR-140-S (on-site laboratory)	9/8/98	0-0.5	0.108	0.176	0.390	0.419	0.942	0.503	0.0132	0.00815				
600835	TJAOU-228A-GR-141-S	9/8/98	0-0.5	0.4	0.1	3.6	3.4	NR	--	0.2	0.1				
600835	TJAOU-228A-GR-142-S	9/8/98	0-0.5	0.4	0.1	5.3	2.0	NR	--	0.3	0.2				
601188	TJAOU-228A-GR-151-S	12/1/98	0-0.5	0.321	0.189	1.31	1.13	0.990	0.123	ND (0.0119)	--				
601213	TJAOU-228A-GR-151-S (on-site laboratory)	12/1/98	0-0.5	0.323	0.198	0.941	0.583	1.03	0.554	ND (0.0393)	--				
601188	TJAOU-228A-GR-152-S	12/1/98	0-0.5	0.106	0.153	0.945	1.28	0.974	0.117	0.0545	0.0315				
601188	TJAOU-228A-GR-153-S	12/1/98	0-0.5	0.0696	0.0979	1.26	0.494	0.960	0.131	ND (0.0115)	--				
601188	TJAOU-228A-GR-154-S	12/1/98	0-0.5	0.297	0.352	1.72	2.21	1.08	0.165	ND (0.0157)	--				
601188	TJAOU-228A-GR-155-S	12/1/98	0-0.5	0.165	0.213	0.518	1.2	1.08	0.133	ND (0.0127)	--				
601188	TJAOU-228A-GR-156-S	12/1/98	0-0.5	0.113	0.14	1.42	1.35	1.13	0.145	ND (0.0118)	--				
601213	TJAOU-228A-GR-156-S (on-site laboratory)	12/1/98	0-0.5	0.101	0.179	2.26	0.614	0.895	0.469	ND (0.0364)	--				
601188	TJAOU-228A-GR-157-S	12/1/98	0-0.5	ND (0.0560)	--	0.941	1.09	1.10	0.138	0.0212	0.0251				
601188	TJAOU-228A-GR-158-S	12/1/98	0-0.5	0.0844	0.121	1.50	0.639	ND (0.0178)	--	0.0259	0.0304				
601188	TJAOU-228A-GR-159-S	12/1/98	0-0.5	0.0864	0.121	1.70	2.01	0.971	0.126	0.0393	0.0324				
601188	TJAOU-228A-GR-160-S	12/1/98	0-0.5	ND (0.0530)	--	1.66	1.12	0.972	0.124	0.0973	0.0345				
601188	TJAOU-228A-GR-161-S	12/1/98	0-0.5	ND (0.0535)	--	1.59	1.15	0.904	0.113	0.0291	0.0348				
601213	TJAOU-228A-GR-161-S (on-site laboratory)	12/1/98	0-0.5	0.136	0.183	1.80	1.25	0.918	0.463	0.0570	0.0319				
601188	TJAOU-228A-GR-161-DU	12/1/98	0-0.5	ND (0.0552)	--	0.857	1.33	1.06	0.132	0.0734	0.0332				
601213	TJAOU-228A-GR-161-DU (on-site laboratory)	12/1/98	0-0.5	0.117	0.185	2.08	0.584	0.794	0.447	0.0421	0.0345				
601213	TJAOU-228A-GR-166-S (on-site laboratory)	12/1/98	0-0.5	ND (0.191)	--	0.582	0.463	0.873	0.479	ND (0.0334)	--				
601189	TJAOU-228A-GR-162-S	12/1/98	0-0.5	0.126	0.166	1.75	1.47	0.891	0.109	0.0553	0.0334				
601189	TJAOU-228A-GR-163-S	12/1/98	0-0.5	0.416	0.198	8.04	1.69	1.20	0.157	0.0215	0.0438				
601189	TJAOU-228A-GR-164-S	12/1/98	0-0.5	0.141	0.155	1.49	1.05	1.04	0.122	0.0106	0.0169				
601189	TJAOU-228A-GR-165-S	12/1/98	0-0.5	0.450	0.38	4.23	2.76	0.995	0.15	0.0412	0.0459				

Refer to footnotes at end of table.

Table 3.4.5-14 (Continued)
Summary of SWMU 228A Site-Confirmatory Sampling Gamma Spectroscopy Analytical Results, September 1998–February 1999
(Off-Site Laboratories, except where indicated)

Sample Attributes				Activity (pCi/g)											
Record Number	ER Sample ID (Figure 3.4.5-8)	Date Sampled	Sample Depth (ft)	Uranium-235		Uranium-238		Thorium-232		Cesium-137					
				Result	Error ^b	Result	Error ^b	Result	Error ^b	Result	Error ^b	Result	Error ^b	Result	Error ^b
601189	TJAOU-228A-GR-166-S	12/1/98	0–0.5	0.132	0.104	0.924	0.985	0.804	0.102	ND (0.00999)	--				
601189	TJAOU-228A-GR-167-S	12/1/98	0–0.5	0.152	0.17	1.35	1.24	1.02	0.133	0.0128	0.0207				
601189	TJAOU-228A-GR-168-S	12/1/98	0–0.5	0.0579	0.15	1.77	1.22	1.05	0.135	0.0185	0.0224				
601189	TJAOU-228A-GR-169-S	12/1/98	0–0.5	0.118	0.235	2.78	1.77	0.970	0.125	0.0295	0.0297				
601189	TJAOU-228A-GR-170-S	12/1/98	0–0.5	0.0689	0.104	1.75	1.48	0.919	0.111	0.144	0.0452				
601189	TJAOU-228A-GR-171-S	12/1/98	0–0.5	0.163	0.19	2.83	1.36	0.890	0.113	0.0555	0.0309				
601213	TJAOU-228A-GR-171-S (on-site laboratory)	12/1/98	0–0.5	ND (0.204)	--	1.72	0.556	0.846	0.476	0.0251	0.0329				
601189	TJAOU-228A-GR-171-DU	12/1/98	0–0.5	0.171	0.208	3.25	1.5	0.976	0.127	0.0296	0.0237				
601213	TJAOU-228A-GR-171-DU (on-site laboratory)	12/1/98	0–0.5	0.115	0.172	1.62	0.528	0.832	0.445	0.0260	0.0251				
601189	TJAOU-228A-GR-172-S	12/1/98	0–0.5	0.0681	0.101	0.853	1	0.943	0.12	ND (0.00910)	--				
601189	TJAOU-228A-GR-173-S	12/1/98	0–0.5	0.105	0.11	1.47	0.698	0.964	0.14	0.0315	0.0254				
601189	TJAOU-228A-GR-174-S	12/1/98	0–0.5	0.172	0.168	0.816	1.79	1.00	0.129	0.0588	0.028				
601189	TJAOU-228A-GR-175-S	12/1/98	0–0.5	ND (0.0534)	--	1.04	1.08	0.922	0.119	0.0775	0.0341				
601190	TJAOU-228A-GR-176-S	12/2/98	0–0.5	0.132	0.102	1.00	1.14	1.01	0.12	ND (0.00882)	--				
601214	TJAOU-228A-GR-176-S (on-site laboratory)	12/2/98	0–0.5	ND (0.187)	--	0.823	0.350	0.886	0.444	0.0165	0.0326				
601190	TJAOU-228A-GR-177-S	12/2/98	0–0.5	0.0792	0.162	1.67	1.34	0.942	0.116	ND (0.0122)	--				
601190	TJAOU-228A-GR-178-S	12/2/98	0–0.5	0.106	0.154	2.74	1.54	1.11	0.14	0.189	0.0738				
601190	TJAOU-228A-GR-179-S	12/2/98	0–0.5	0.102	0.175	2.47	1.37	1.03	0.125	0.0691	0.0341				
601190	TJAOU-228A-GR-180-S	12/2/98	0–0.5	0.162	0.105	1.33	1.37	0.930	0.118	0.169	0.0356				
601190	TJAOU-228A-GR-181-S	12/2/98	0–0.5	0.167	0.225	2.18	1.5	1.24	0.151	0.114	0.0375				
601214	TJAOU-228A-GR-181-S (on-site laboratory)	12/2/98	0–0.5	0.108	0.169	3.40	0.903	0.781	0.413	0.0617	0.0378				
601190	TJAOU-228A-GR-181-DU	12/2/98	0–0.5	0.150	0.143	2.75	0.762	1.01	0.133	0.0823	0.0402				
601214	TJAOU-228A-GR-181-DU (on-site laboratory)	12/2/98	0–0.5	0.157	0.166	1.51	0.618	0.776	0.417	0.0811	0.0392				
601190	TJAOU-228A-GR-182-S	12/2/98	0–0.5	0.122	0.105	1.25	1.1	1.13	0.133	0.105	0.0327				
601190	TJAOU-228A-GR-183-S	12/2/98	0–0.5	0.159	0.173	1.59	1.19	0.941	0.115	0.106	0.0387				
601190	TJAOU-228A-GR-184-S	12/2/98	0–0.5	ND (0.0631)	--	1.53	1.41	0.774	0.124	0.0889	0.0392				
601190	TJAOU-228A-GR-185-S	12/2/98	0–0.5	ND (0.0560)	--	3.13	1.29	0.940	0.121	0.135	0.0445				
601190	TJAOU-228A-GR-186-S	12/2/98	0–0.5	0.141	0.121	1.72	1.75	0.920	0.121	0.141	0.0369				
601214	TJAOU-228A-GR-186-S (on-site laboratory)	12/2/98	0–0.5	0.136	0.167	1.88	0.520	0.712	0.337	0.108	0.0426				

Refer to footnotes at end of table.

Table 3.4.5-14 (Continued)
Summary of SWMU 228A Site-Confirmatory Sampling Gamma Spectroscopy Analytical Results, September 1998–February 1999
(Off-Site Laboratories, except where indicated)

Sample Attributes				Activity (pCi/g)											
Record Number	ER Sample ID (Figure 3.4.5-8)	Date Sampled	Sample Depth (ft)	Uranium-235		Uranium-238		Thorium-232		Cesium-137					
				Result	Error ^b	Result	Error ^b	Result	Error ^b	Result	Error ^b	Result	Error ^b	Result	Error ^b
601190	TJAOU-228A-GR-187-S	12/2/98	0–0.5	ND (0.0638)	--	3.46	1.52	0.977	0.125	0.0620	0.0317				
601191	TJAOU-228A-GR-188-S	12/2/98	0–0.5	0.177	0.178	1.35	1.06	0.844	0.107	0.132	0.0416				
601191	TJAOU-228A-GR-189-S	12/2/98	0–0.5	0.0612	0.11	2.70	1.65	0.836	0.109	0.0860	0.0364				
601191	TJAOU-228A-GR-190-S	12/2/98	0–0.5	ND (0.0629)	--	1.26	0.632	0.873	0.157	0.218	0.0746				
601191	TJAOU-228A-GR-191-S	12/2/98	0–0.5	0.0494	0.147	1.41	1.49	0.861	0.106	0.114	0.037				
601214	TJAOU-228A-GR-191-S (on-site laboratory)	12/2/98	0–0.5	0.102	0.173	2.53	0.817	0.815	0.425	0.0983	0.0442				
601191	TJAOU-228A-GR-191-DU	12/2/98	0–0.5	0.136	0.125	1.43	0.593	0.930	0.124	0.0848	0.0472				
601214	TJAOU-228A-GR-191-DU (on-site laboratory)	12/2/98	0–0.5	0.171	0.166	1.65	0.674	0.827	0.455	0.108	0.0679				
601191	TJAOU-228A-GR-192-S	12/2/98	0–0.5	0.343	0.314	0.830	2.2	0.863	0.136	0.0445	0.057				
601191	TJAOU-228A-GR-193-S	12/2/98	0–0.5	0.128	0.226	1.89	1.46	0.948	0.116	0.104	0.0494				
601191	TJAOU-228A-GR-194-S	12/2/98	0–0.5	0.207	0.164	1.50	1.36	0.915	0.115	0.230	0.0547				
601191	TJAOU-228A-GR-195-S	12/2/98	0–0.5	0.327	0.211	2.28	1.52	1.09	0.14	0.0432	0.034				
601191	TJAOU-228A-GR-196-S	12/2/98	0–0.5	0.124	0.169	2.29	1.41	0.955	0.125	0.0982	0.0358				
601214	TJAOU-228A-GR-196-S (on-site laboratory)	12/2/98	0–0.5	ND (0.192)	--	1.73	0.529	0.667	0.374	ND (0.0231)	--				
601191	TJAOU-228A-GR-197-S	12/2/98	0–0.5	0.114	0.201	1.87	0.734	ND (0.0165)	--	0.0676	0.0374				
601191	TJAOU-228A-GR-198-S	12/2/98	0–0.5	0.0584	0.0992	1.92	1.75	0.849	0.111	0.108	0.0368				
601191	TJAOU-228A-GR-199-S	12/2/98	0–0.5	ND (0.0540)	--	2.28	1.34	0.835	0.11	0.107	0.0512				
601191	TJAOU-228A-GR-200-S	12/2/98	0–0.5	0.0804	0.126	1.92	1.37	0.938	0.123	0.115	0.0313				
601192	TJAOU-228A-GR-201-S	12/3/98	0–0.5	0.198	0.123	1.03	1.2	0.862	0.111	0.215	0.0504				
601215	TJAOU-228A-GR-201-S (on-site laboratory)	12/3/98	0–0.5	0.0638	0.0695	2.84	0.811	0.689	0.352	0.165	0.0414				
601192	TJAOU-228A-GR-201-DU	12/3/98	0–0.5	0.0852	0.172	1.32	1.38	0.916	0.117	0.285	0.0524				
601215	TJAOU-228A-GR-201-DU (on-site laboratory)	12/3/98	0–0.5	0.230	0.200	1.71	0.545	0.747	0.376	0.169	0.0438				
601192	TJAOU-228A-GR-202-S	12/3/98	0–0.5	0.220	0.214	2.64	1.22	0.999	0.122	0.250	0.0551				
601192	TJAOU-228A-GR-203-S	12/3/98	0–0.5	ND (0.0574)	--	1.28	0.584	0.979	0.13	0.0919	0.0407				
601192	TJAOU-228A-GR-204-S	12/3/98	0–0.5	0.0869	0.151	1.48	0.945	0.819	0.099	0.119	0.0391				
601192	TJAOU-228A-GR-205-S	12/3/98	0–0.5	ND (0.0749)	--	2.08	2.04	0.768	0.126	0.139	0.056				
601192	TJAOU-228A-GR-206-S	12/3/98	0–0.5	0.147	0.16	1.45	0.658	1.08	0.142	0.119	0.0659				
601215	TJAOU-228A-GR-206-S (on-site laboratory)	12/3/98	0–0.5	ND (0.225)	--	0.979	0.504	0.911	0.599	0.143	0.0397				

Refer to footnotes at end of table.

Table 3.4.5-14 (Continued)
Summary of SWMU 228A Site-Confirmatory Sampling Gamma Spectroscopy Analytical Results, September 1998–February 1999
(Off-Site Laboratories, except where indicated)

Record Number	Sample Attributes		Activity (pCi/g)											
	ER Sample ID (Figure 3.4.5-8)	Date Sampled	Sample Depth (ft)	Uranium-235		Uranium-238		Thorium-232		Cesium-137				
				Result	Error ^b	Result	Error ^b	Result	Error ^b	Result	Error ^b	Result	Error ^b	
601192	TJAOU-228A-GR-207-S	12/3/98	0-0.5	ND (0.0644)	--	0.866	1.21	0.949	0.118	0.0955	0.0496			
601192	TJAOU-228A-GR-208-S	12/3/98	0-0.5	0.139	0.215	3.28	1.77	0.986	0.131	0.252	0.0641			
601192	TJAOU-228A-GR-209-S	12/3/98	0-0.5	0.234	0.239	2.15	1.87	0.973	0.135	0.286	0.0583			
601192	TJAOU-228A-GR-210-S	12/3/98	0-0.5	0.169	0.118	1.29	1.25	0.819	0.112	0.341	0.0599			
601192	TJAOU-228A-GR-211-S	12/3/98	0-0.5	ND (0.0715)	--	0.635	1.52	0.870	0.117	0.0517	0.0318			
601215	TJAOU-228A-GR-211-S (on-site laboratory)	12/3/98	0-0.5	ND (0.236)	--	0.541	0.495	0.704	0.371	0.0433	0.0184			
601192	TJAOU-228A-GR-211-DU	12/3/98	0-0.5	ND (0.0735)	--	1.17	1.26	0.882	0.119	0.0819	0.0489			
601215	TJAOU-228A-GR-211-DU (on-site laboratory)	12/3/98	0-0.5	ND (0.248)	--	0.713	0.453	0.715	0.390	0.0449	0.0203			
601212	TJAOU-228A-GR-212-S	12/3/98	0-0.5	ND (0.0760)	--	0.449	0.979	1.02	0.128	0.121	0.0384			
601212	TJAOU-228A-GR-213-S	12/3/98	0-0.5	ND (0.0953)	--	ND (0.572)	--	0.785	0.111	0.0751	0.034			
601212	TJAOU-228A-GR-214-S	12/3/98	2-3	0.0842	0.11	1.42	1.77	0.656	0.0919	ND (0.0121)	--			
601212	TJAOU-228A-GR-215-S	12/3/98	2-3	ND (0.0732)	--	0.971	1.91	1.08	0.159	ND (0.0127)	--			
601212	TJAOU-228A-GR-216-S	12/3/98	2-3	0.135	0.186	1.13	0.717	0.969	0.146	ND (0.0132)	--			
601215	TJAOU-228A-GR-216-S (on-site laboratory)	12/3/98	2-3	0.157	0.237	0.923	0.497	0.767	0.387	ND (0.0401)	--			
601212	TJAOU-228A-GR-217-S	12/3/98	0-0.5	0.113	0.176	3.08	1.6	1.00	0.122	ND (0.0110)	--			
601619	TJAOU-228A-GR-229-S (on-site laboratory)	2/15/99	0-0.5	ND (0.200)	--	ND (0.695)	--	0.882	0.452	0.0531	0.0307			
601619	TJAOU-228A-GR-230-S (on-site laboratory)	2/15/99	0-0.5	0.107	0.164	0.592	0.534	0.832	0.425	0.0428	0.0263			
601619	TJAOU-228A-GR-231-S (on-site laboratory)	2/15/99	0-0.5	ND (0.240)	--	ND (0.796)	--	0.835	0.453	0.621	0.109			
601619	TJAOU-228A-GR-232-S (on-site laboratory)	2/15/99	0-0.5	0.0903	0.150	ND (0.628)	--	0.907	0.442	0.0959	0.0331			
601619	TJAOU-228A-GR-233-S (on-site laboratory)	2/15/99	0-0.5	ND (0.189)	--	ND (0.651)	--	0.828	0.424	0.104	0.0370			

Refer to footnotes at end of table.

Table 3.4.5-14 (Continued)
Summary of SWMU 228A Site-Confirmatory Sampling Gamma Spectroscopy Analytical Results, September 1998–February 1999
(Off-Site Laboratories, except where indicated)

Record Number ^a	Sample Attributes		Sample Depth (ft)	Activity (pCi/g)											
	ER Sample ID (Figure 3.4.5-8)	Date Sampled		Uranium-235		Uranium-238		Thorium-232		Cesium-137					
				Result	Error ^b	Result	Error ^b	Result	Error ^b	Result	Error ^b	Result	Error ^b	Result	Error ^b
601619	TJAOU-228A-GR-234-S (on-site laboratory)	2/15/99	0–0.5	ND (0.199)	--	ND (0.668)	--	0.853	0.779	0.0254	0.0238				
601619	TJAOU-228A-GR-235-S (on-site laboratory)	2/15/99	0–0.5	ND (0.221)	--	ND (0.736)	--	0.961	0.506	0.456	0.0836				
601619	TJAOU-228A-GR-236-S (on-site laboratory)	2/15/99	0–0.5	0.108	0.164	ND (0.709)	--	0.738	1.44	0.119	0.0392				
601619	TJAOU-228A-GR-237-S (on-site laboratory)	2/15/99	0–0.5	ND (0.206)	--	ND (0.691)	--	0.754	0.404	0.0380	0.0243				
601619	TJAOU-228A-GR-238-S (on-site laboratory)	2/15/99	0–0.5	ND (0.206)	--	ND (0.723)	--	0.806	0.426	ND (0.0280)	--				
601620	TJAOU-228A-GR-239-S (on-site laboratory)	2/15/99	0–0.5	ND (0.218)	--	ND (0.732)	--	0.799	0.445	0.190	0.0500				
601620	TJAOU-228A-GR-240-S (on-site laboratory)	2/15/99	0–0.5	ND (0.207)	--	ND (0.736)	--	0.787	0.429	0.0210	0.0272				
601620	TJAOU-228A-GR-241-S (on-site laboratory)	2/15/99	0–0.5	ND (0.225)	--	ND (0.796)	--	0.760	0.430	ND (0.0311)	--				
601620	TJAOU-228A-GR-242-S (on-site laboratory)	2/15/99	0–0.5	ND (0.199)	--	ND (0.659)	--	0.746	0.398	0.0420	0.0322				
601620	TJAOU-228A-GR-243-S (on-site laboratory)	2/15/99	0–0.5	ND (0.223)	--	ND (0.781)	--	0.733	0.423	0.277	0.0638				
601620	TJAOU-228A-GR-244-S (on-site laboratory)	2/15/99	0–0.5	0.105	0.174	ND (0.751)	--	0.820	0.416	0.0766	0.0373				
601620	TJAOU-228A-GR-245-S (on-site laboratory)	2/15/99	0–0.5	ND (0.200)	--	ND (0.687)	--	0.841	0.436	0.0368	0.0182				
601620	TJAOU-228A-GR-246-S (on-site laboratory)	2/15/99	0–0.5	ND (0.200)	--	ND (0.687)	--	0.825	0.440	0.0366	0.0244				
601620	TJAOU-228A-GR-247-S (on-site laboratory)	2/15/99	0–0.5	ND (0.204)	--	ND (0.682)	--	0.865	0.433	ND (0.0281)	--				
601620	TJAOU-228A-GR-248-S (on-site laboratory)	2/15/99	0–0.5	ND (0.226)	--	ND (0.785)	--	1.21	0.616	0.0247	0.0215				
601620	TJAOU-228A-GR-249-S (on-site laboratory)	2/15/99	0–0.5	0.0912	0.153	ND (0.647)	--	0.839	0.0424	0.0150	0.0273				
Background Soil Concentrations - North Supergroup ^c				0.18		1.3		1.54		0.836 (surface) 0.084 (subsurface)					

Refer to footnotes at end of table.

Table 3.4.5-14 (Concluded)
 Summary of SWMU 228A Site-Confirmatory Sampling Gamma Spectroscopy Analytical Results, September 1998–February 1999
 (Off-Site Laboratories, except where indicated.)

Sample Attributes				Activity (pCi/g)							
Record Number ^a	ER Sample ID (Figure 3.4.5-8)	Date Sampled	Sample Depth (ft)	Uranium-235 ^b		Uranium-238 ^b		Thorium-232 ^b		Cesium-137 ^b	
				Result	Error ^b	Result	Error ^b	Result	Error ^b	Result	Error ^b
Quality Assurance/Quality Control Samples (all in pCi/L)											
600836	TJAOU-228A-GR-EB	9/8/98	NA	8.4	3.8	93.2	91.2	NR	--	2.4	1.7
600836	TJAOU-228A-GR-EB	9/9/98	NA	18.9	4.8	323	31.8	NR	--	1.3	1.9
601189	TJAOU-228A-EB	12/1/98	NA	ND (11.5)	--	ND (136)	--	ND (3.26)	--	ND (2.27)	--
601191	TJAOU-228A-EB	12/2/98	NA	ND (10.1)	--	ND (72.4)	--	4.67	7.6	ND (2.10)	--
601212	TJAOU-228A-EB	12/3/98	NA	13.2	28.3	143	98.3	ND (3.80)	--	ND (2.20)	--
601620	TJAOU-228A-GR-EB2 (on-site laboratory)	2/15/99	NA	ND (0.113)	--	ND (0.332)	--	ND (0.113)	--	ND (0.0180)	--

Note: Values in **bold** exceed background soil activities.

^a Analysis request/chain of custody.

^b Two standard deviations about the mean detected activity.

^c From Dinwiddie September 1997. The minimum background activity between surface and subsurface values is used.

DU = Duplicate sample.

EB = Equipment blank.

ER = Environmental Restoration.

ft = Foot (feet).

GR = Grab sample.

ID = Identification.

NA = Not applicable.

ND () = Not detected above the minimum detectable activity, shown in parentheses.

NR = Not reported.

pCi/g = Picocurie(s) per gram.

pCi/L = Picocurie(s) per liter.

S = Soil sample.

SWMU = Solid Waste Management Unit.

TJAOU = Tijeras Arroyo Operable Unit.

-- = Error not calculated for nondetectable results.

Table 3.4.5-15
Summary of SWMU 228A Soil Piles Confirmatory Sampling Gamma Spectroscopy Analytical Results, September–December 1998
(Off-Site Laboratories, except where indicated)

Record Number ^a	Sample Attributes			Activity (pCi/g)											
	ER Sample ID (Figure 3.4.5-8)	Date Sampled	Sample Depth (ft)	Uranium-235		Uranium-238		Thorium-232		Cesium-137					
				Result	Error ^b	Result	Error ^b	Result	Error ^b	Result	Error ^b	Result	Error ^b	Result	Error ^b
600800	TJAOU-228A-GR-143-S (on-site laboratory)	9/9/98	0–0.5	0.135	0.164	ND (0.457)	--	0.809	0.419	0.0243	0.0250				
600835	TJAOU-228A-GR-143-S	9/9/98	0–0.5	0.2	0.2	4.0	3.9	NR	--	0.1	0.1				
600835	TJAOU-228A-GR-144-S	9/9/98	0–0.5	0.2	0.1	2.9	3.6	NR	--	0.2	0.1				
600800	TJAOU-228A-GR-145-S (on-site laboratory)	9/9/98	0–0.5	0.145	0.169	ND (0.524)	--	0.941	0.505	ND (0.0342)	--				
600835	TJAOU-228A-GR-145-S	9/9/98	0–0.5	0.4	0.1	8.4	2.4	NR	--	0.4	0.2				
600835	TJAOU-228A-GR-146-S	9/9/98	0–0.5	0.2	0.4	6.1	4.3	NR	--	0.1	0.0				
600800	TJAOU-228A-GR-147-S (on-site laboratory)	9/9/98	0–0.5	0.119	0.157	ND (0.495)	--	0.845	0.440	0.0770	0.0464				
600835	TJAOU-228A-GR-147-S	9/9/98	0–0.5	0.4	0.2	6.8	2.8	NR	--	0.4	0.2				
600835	TJAOU-228A-GR-148-S	9/9/98	0–0.5	0.1	0.1	6.7	5.3	NR	--	0.2	0.1				
600800	TJAOU-228A-GR-149-S (on-site laboratory)	9/9/98	0–0.5	ND (0.101)	--	4.71	0.978	0.946	0.502	0.0396	0.0315				
600835	TJAOU-228A-GR-149-S	9/9/98	0–0.5	0.4	0.2	4.1	4.3	NR	--	0.2	0.1				
600835	TJAOU-228A-GR-150-S	9/9/98	0–0.5	0.1	0.2	5.3	3.3	NR	--	0.2	0.1				
601212	TJAOU-228A-GR-218-S	12/3/98	0–0.5	0.239	0.19	2.65	1.35	0.893	0.11	0.0641	0.0338				
601212	TJAOU-228A-GR-219-S	12/3/98	0–0.5	0.138	0.118	2.67	1.43	0.970	0.127	0.0552	0.0326				
601212	TJAOU-228A-GR-220-S	12/3/98	0–0.5	0.129	0.18	1.42	0.981	0.961	0.123	0.0650	0.0444				
601212	TJAOU-228A-GR-221-S	12/3/98	0–0.5	ND (0.0587)	--	1.60	0.757	ND (0.0192)	--	0.0111	0.02				
601215	TJAOU-228A-GR-221-S (on-site laboratory)	12/3/98	0–0.5	0.209	0.376	8.22	1.94	0.904	1.63	0.0518	0.0271				
601212	TJAOU-228A-GR-221-DU	12/3/98	0–0.5	0.0750	0.159	1.96	1.85	0.918	0.119	0.0224	0.0226				
601215	TJAOU-228A-GR-221-DU (on-site laboratory)	12/3/98	0–0.5	ND (0.223)	--	1.18	0.498	0.852	0.398	0.0443	0.0244				
601212	TJAOU-228A-GR-222-S	12/3/98	0–0.5	0.284	0.201	2.05	1.32	1.00	0.126	0.0996	0.038				
601212	TJAOU-228A-GR-223-S	12/3/98	0–0.5	0.103	0.101	1.98	1.18	0.882	0.11	0.0660	0.0444				
601212	TJAOU-228A-GR-224-S	12/3/98	0–0.5	0.0553	0.113	1.83	1.2	1.13	0.139	0.0707	0.051				
601212	TJAOU-228A-GR-225-S	12/3/98	0–0.5	ND (0.0412)	--	2.64	0.764	1.08	0.151	0.0928	0.0455				
601212	TJAOU-228A-GR-226-S	12/3/98	0–0.5	0.217	0.168	1.61	0.775	0.934	0.128	0.162	0.108				
601215	TJAOU-228A-GR-226-S (on-site laboratory)	12/3/98	0–0.5	0.121	0.209	0.929	0.605	0.944	0.748	0.153	0.0384				
601212	TJAOU-228A-GR-227-S	12/3/98	0–0.5	0.0747	0.163	0.994	1.18	0.965	0.118	0.184	0.0487				
601212	TJAOU-228A-GR-228-S	12/3/98	0–0.5	0.0685	0.182	0.702	1.2	0.959	0.121	0.194	0.0593				
Background Soil Concentrations—North Supergroup ^c				0.18		1.3		1.54		0.836 (surface) 0.084 (subsurface)					

Refer to footnotes at end of table.

Summary of SWMU 228A Soil Piles Confirmatory Sampling Gamma Spectroscopy Analytical Results, September-December 1998
(Off-Site Laboratories, except where indicated)

Note: Values in **bold** exceed background soil activities.

^a Analysis request/chain of custody.

^b Two standard deviations about the mean detected activity.

^c From Dinwiddie September 1997. The minimum background activity between surface and subsurface values is used.

DU = Duplicate sample.

ER = Environmental Restoration.

ft = Foot (feet).

GR = Grab Sample.

ID = Identification.

ND () = Not detected above the minimum detectable activity, shown in parentheses.

NR = Not reported.

pCi/g = Picocurie(s) per gram.

S = Soil sample.

SWMU = Solid Waste Management Unit.

TJAOU = Tijeras Arroyo Operable Unit.

- = Error not calculated for nondetectable results.

Table 3.4.5-16
Summary of SWMU 228A Site-Confirmatory Sampling
Isotopic Uranium (Alpha Spectroscopy) Analytical Results, September-December 1998
(Off-Site Laboratories)

Sample Attributes				Activity (pCi/g)					
Record Number ^a	ER Sample ID (Figure 3.4.5-8)	Date Sampled	Sample Depth (ft)	Uranium-233/234		Uranium-235		Uranium-238	
				Result	Error ^b	Result	Error ^b	Result	Error ^b
600799	TJAOU-228A-GR-120-S	9/8/98	0-0.5	0.670	0.250	0.0300	0.0500	0.750	0.250
600799	TJAOU-228A-GR-121-S	9/8/98	0-0.5	0.460	0.200	0.0400	0.0600	0.530	0.200
600799	TJAOU-228A-GR-122-S	9/8/98	0-0.5	0.790	0.280	0.0100	0.0300	0.880	0.290
600799	TJAOU-228A-GR-123-S	9/8/98	0-0.5	0.790	0.300	0.0500	0.0800	1.14	0.350
600799	TJAOU-228A-GR-123-DU	9/8/98	0-0.5	0.760	0.270	0.0300	0.0600	0.930	0.300
600799	TJAOU-228A-GR-124-S	9/8/98	0-0.5	1.32	0.370	0.110	0.100	1.19	0.340
600799	TJAOU-228A-GR-125-S	9/8/98	0-0.5	0.680	0.240	0.0200	0.0400	0.930	0.280
600799	TJAOU-228A-GR-126-S	9/8/98	0-0.5	1.08	0.320	0.00	0.0100	1.36	0.370
600799	TJAOU-228A-GR-127-S	9/8/98	0-0.5	0.790	0.270	0.100	0.0900	1.21	0.340
600799	TJAOU-228A-GR-128-S	9/8/98	0-0.5	0.840	0.290	0.0700	0.0800	0.830	0.280
600799	TJAOU-228A-GR-129-S	9/8/98	0-0.5	0.630	0.270	0.0100	0.0400	1.25	0.380
600799	TJAOU-228A-GR-130-S	9/8/98	0-0.5	0.480	0.210	0.0400	0.0600	0.920	0.300
600799	TJAOU-228A-GR-131-S	9/8/98	0-0.5	0.680	0.270	0.0600	0.0800	0.760	0.280
600799	TJAOU-228A-GR-132-S	9/8/98	0-0.5	0.970	0.300	0.00	0.0100	0.610	0.220
600835	TJAOU-228A-GR-133-S	9/8/98	0-0.5	0.830	0.300	0.0600	0.0800	0.900	0.300
600835	TJAOU-228A-GR-133-DU	9/8/98	0-0.5	0.820	0.270	0.0500	0.0600	0.840	0.270
600835	TJAOU-228A-GR-134-S	9/8/98	0-0.5	0.640	0.240	0.00	0.0100	0.890	0.290
600835	TJAOU-228A-GR-135-S	9/8/98	0-0.5	1.33	0.380	0.0700	0.0800	0.870	0.290
600835	TJAOU-228A-GR-136-S	9/8/98	0-0.5	0.830	0.290	0.0700	0.0800	1.05	0.320
600835	TJAOU-228A-GR-137-S	9/8/98	0-0.5	1.37	0.380	0.110	0.100	1.57	0.410
600835	TJAOU-228A-GR-138-S	9/8/98	0-0.5	1.14	0.360	0.0800	0.0800	0.990	0.320
600835	TJAOU-228A-GR-139-S	9/8/98	0-0.5	0.830	0.270	0.0900	0.0900	0.770	0.260
600835	TJAOU-228A-GR-140-S	9/8/98	0-0.5	1.03	0.330	0.0100	0.0400	1.09	0.330
600835	TJAOU-228A-GR-141-S	9/8/98	0-0.5	0.800	0.290	0.0100	0.0300	1.00	0.320
600835	TJAOU-228A-GR-142-S	9/8/98	0-0.5	0.850	0.300	0.110	0.100	0.850	0.290
601188	TJAOU-228A-GR-151-S	12/1/98	0-0.5	0.798	0.137	0.0533	0.03	0.786	0.135
601188	TJAOU-228A-GR-151-S	12/1/98	0-0.5	0.831	0.133	0.0721	0.0329	0.958	0.147
601188	TJAOU-228A-GR-156-S	12/1/98	0-0.5	0.871	0.142	0.0690	0.0358	1.30	0.187
601188	TJAOU-228A-GR-161-S	12/1/98	0-0.5	1.15	0.181	0.0655	0.0367	1.62	0.23
601188	TJAOU-228A-GR-161-DU	12/1/98	0-0.5	0.911	0.149	0.0658	0.0335	0.848	0.143
601189	TJAOU-228A-GR-166-S	12/1/98	0-0.5	0.911	0.149	0.0658	0.0335	0.848	0.143
601189	TJAOU-228A-GR-166-S	12/1/98	0-0.5	0.911	0.149	0.0658	0.0335	0.848	0.143
601189	TJAOU-228A-GR-171-S	12/1/98	0-0.5	1.17	0.187	0.0714	0.0375	2.25	0.297
601189	TJAOU-228A-GR-171-S	12/1/98	0-0.5	1.17	0.187	0.0714	0.0375	2.25	0.297
601189	TJAOU-228A-GR-171-DU	12/1/98	0-0.5	1.30	0.192	0.0975	0.0417	2.28	0.29
601189	TJAOU-228A-GR-171-DU	12/1/98	0-0.5	1.30	0.192	0.0975	0.0417	2.28	0.29
601190	TJAOU-228A-GR-176-S	12/2/98	0-0.5	0.734	0.21	0.0371	0.043	0.888	0.231
601190	TJAOU-228A-GR-176-S	12/2/98	0-0.5	0.734	0.21	0.0371	0.043	0.888	0.231
601190	TJAOU-228A-GR-181-S	12/2/98	0-0.5	0.976	0.257	0.0821	0.0677	2.62	0.481
601190	TJAOU-228A-GR-181-S	12/2/98	0-0.5	0.976	0.257	0.0821	0.0677	2.62	0.481
601190	TJAOU-228A-GR-181-DU	12/2/98	0-0.5	0.856	0.243	0.0793	0.0717	1.59	0.353
601190	TJAOU-228A-GR-181-DU	12/2/98	0-0.5	0.856	0.243	0.0793	0.0717	1.59	0.353
601190	TJAOU-228A-GR-186-S	12/2/98	0-0.5	0.760	0.229	0.0541	0.0583	2.01	0.411
601191	TJAOU-228A-GR-191-S	12/2/98	0-0.5	0.976	0.251	0.0389	0.0451	1.38	0.309

Refer to footnotes at end of table.

Table 3.4.5-16 (Concluded)
Summary of SWMU 228A Site-Confirmatory Sampling
Isotopic Uranium (Alpha Spectroscopy) Analytical Results, September–December 1998
(Off-Site Laboratories)

Sample Attributes			Activity (pCi/g)					
Record Number ^a	ER Sample ID (Figure 3.4.5-8)	Date Sampled	Sample Depth (ft)	Uranium-233/234 ^b		Uranium-235 ^c		Uranium-238 ^d
				Result	Error	Result	Error	Result
601191	TJAOU-228A-GR-191-DU	12/2/98	0–0.5	0.770	0.227	ND (0.0250)	--	1.60
601191	TJAOU-228A-GR-196-S	12/2/98	0–0.5	0.884	0.333	ND (0.0211)	--	1.33
601192	TJAOU-228A-GR-201-S	12/3/98	0–0.5	0.702	0.168	0.0371	0.0361	1.16
601192	TJAOU-228A-GR-201-DU	12/3/98	0–0.5	0.694	0.149	0.0675	0.0441	1.28
601192	TJAOU-228A-GR-206-S	12/3/98	0–0.5	0.863	0.165	0.0318	0.0324	0.869
601192	TJAOU-228A-GR-211-S	12/3/98	0–0.5	0.677	0.137	0.0366	0.0358	0.680
601192	TJAOU-228A-GR-211-DU	12/3/98	0–0.5	0.842	0.159	0.0433	0.0309	0.758
601212	TJAOU-228A-GR-216-S	12/3/98	2–3	0.657	0.137	0.0354	0.0296	0.584
Background Soil Concentrations—North Area Supergroup ^e				1.6	NA	0.18	NA	1.3
Quality Assurance/Quality Control Samples (all in pCi/L)								
600836	TJAOU-228A-GR-EB	9/8/98	NA	0.0400	0.130	0.0700	0.110	0.140
600836	TJAOU-228A-GR-EB	9/8/98	NA	0.0500	0.130	0.0100	0.0600	0.00
601189	TJAOU-228A-EB	12/2/98	NA	0.0638	0.032	ND (0.0209)	--	0.0366
601191	TJAOU-228A-EB	12/2/98	NA	0.0384	0.0323	0.0385	0.0239	0.0438
601212	TJAOU-228A-TB	12/3/98	NA	0.0504	0.0288	0.0323	0.0245	0.0383
								0.0259

Note: Values in **bold** exceed background soil activities.

^a Analysis request/chain of custody.

^b Two standard deviations about the mean detected activity.

^c From Dinwiddle September 1997. The minimum background activity between surface and subsurface values is used.

DU = Duplicate sample.
 EB = Equipment blank.
 ER = Environmental Restoration.

ft = Foot (feet).

GR = Grab sample.

ID = Identification.

NA = Not applicable.

ND () = Not detected above the minimum detectable activity, shown in parentheses.

pCi/g = PicoCurie(s) per gram.

pCi/L = PicoCurie(s) per liter.

S = Soil sample.

SWMU = Solid Waste Management Unit.

TB = Trip blank.

TJAOU = Tijeras Arroyo Operable Unit.

-- = Error not calculated for nondetectable results.

Table 3.4.5-17
Summary of SWMU 228A Soil Piles Confirmatory Sampling
Isotopic Uranium (Alpha Spectroscopy) Analytical Results,
September–December 1998
(Off-Site Laboratories)

Sample Attributes			Activity (pCi/g)					
Record Number ^a	ER Sample ID (Figure 3.4.5-8)	Date Sampled	Sample Depth (ft)	Uranium-233/234 ^b		Uranium-235 ^b		Uranium-238 ^b
				Result	Error	Result	Error	Result
600835	TJAOU-228A-GR-143-S	9/9/98	0-0.5	0.780	0.280	0.0600	0.0700	0.830
600835	TJAOU-228A-GR-144-S	9/9/98	0-0.5	0.670	0.240	0.0500	0.0600	0.680
600835	TJAOU-228A-GR-145-S	9/9/98	0-0.5	0.960	0.310	0.140	0.110	0.870
600835	TJAOU-228A-GR-146-S	9/9/98	0-0.5	0.720	0.260	0.0500	0.0700	0.800
600835	TJAOU-228A-GR-147-S	9/9/98	0-0.5	0.820	0.280	0.0300	0.0500	0.700
600835	TJAOU-228A-GR-148-S	9/9/98	0-0.5	0.570	0.250	0.100	0.0900	0.950
600835	TJAOU-228A-GR-149-S	9/9/98	0-0.5	1.64	0.440	0.0400	0.0700	2.38
600835	TJAOU-228A-GR-150-S	9/9/98	0-0.5	1.19	0.370	0.0900	0.100	2.47
600835	TJAOU-228A-GR-221-S	12/3/98	0-0.5	1.23	0.209	0.101	0.0519	1.68
601212	TJAOU-228A-GR-221-DU	12/3/98	0-0.5	1.06	0.183	0.0711	0.04	1.71
601212	TJAOU-228A-GR-226-S	12/3/98	0-0.5	0.832	0.16	0.0286	0.0257	1.06
Background Soil Concentrations—North Area Supergroup ^c				1.6	NA	0.18	NA	1.3
								NA

Note: Values in bold exceed background soil activities.

^a Analysis request/chain of custody.

^b Two standard deviations about the mean detected activity.

^c From Dinwiddie September 1997. The minimum background activity between surface and subsurface values is used.

DU = Duplicate sample.

ER = Environmental Restoration.

ft = Foot (feet).

GR = Grab sample.

ID = Identification.

NA = Not applicable.

pCi/g = Picocurie(s) per gram.

S = Soil sample.

SWMU = Solid Waste Management Unit.

TJAOU = Tijeras Arroyo Operable Unit.

Arsenic, chromium, mercury, selenium, and silver were not detected above the background concentration limit in any of the soil samples collected at SWMU 228A. Barium was detected at slightly above the background concentration limit in two samples from site-confirmatory locations (TJAOU-228A-GR-133-S and TJAOU-228A-GR-140-S) but was not detected above background in the duplicate sample TJAOU-228A-GR-133-DU. Barium was also detected at slightly above the background concentration limit in one soil pile sample (TJAOU-228A-GR-144-S). Cadmium was detected at levels above the background concentration limit in two site-confirmatory samples (TJAOU-228A-GR-129-S and TJAOU-228A-GR-209-S). Lead was detected at levels above the background concentration limit in five site-confirmatory samples (TJAOU-228A-GR-129-S, TJAOU-228A-GR-133-S, TJAOU-228A-GR-140-S, TJAOU-228A-GR-163-S, and TJAOU-228A-GR-209-S). However, lead was not detected above background in the duplicate sample TJAOU-228A-GR-133-DU. Additionally, two of the samples were laboratory estimated values (TJAOU-228A-GR-133-S and TJAOU-228A-GR-140-S). Lead was detected at levels above the background concentration limit in four soil pile samples (TJAOU-228A-GR-143-S, TJAOU-228A-GR-144-S, TJAOU-228A-GR-147-S, and TJAOU-228A-GR-148-S), although all of these were laboratory estimated values. Total uranium was detected above the background concentration limit in all soil samples for which uranium analyses were performed (14 site-confirmatory samples and 8 soil pile samples).

HE

No HE compounds were detected in any of the soil samples collected at SWMU 228A. Because there are no background concentrations for HE compounds in soil, any detectable HE compounds in the samples collected at SWMU 228A would have been considered an indication of contamination. Table 3.4.5-7 summarizes the detection limits for analysis of HE compounds by the off-site laboratories.

VOCs

Tables 3.4.5-8 and 3.4.5-9 summarize the off-site VOC analytical results for both the site-confirmatory sampling (19 surface soil samples, 1 subsurface soil sample, 8 duplicate samples, 4 equipment blank samples, and 4 trip blank samples) and the soil piles sampling (6 surface soil samples and 1 duplicate sample), respectively. Only two VOCs, benzene and methylene chloride, were detected in soil. However, the detections were in the single-digit $\mu\text{g}/\text{kg}$ range and most were 'J' values. The maximum benzene and methylene chloride concentrations were 1.2 and 7.2 $\mu\text{g}/\text{kg}$, respectively. Methylene chloride is a common analytical laboratory contaminant (Bleyler February 1988), and was detected in three of the QA/QC samples.

Because there are no established background concentrations for VOC compounds in soil, any detectable VOCs in the samples collected at SWMU 228A were considered an indication of contamination for risk assessment purposes. Benzene was detected in one site-confirmatory soil sample (TJAOU-228A-GR-133-S), although it was not detected in the duplicate soil sample from that location (TJAOU-228A-GR-133-DU). Methylene chloride was detected in six site-confirmatory soil samples (TJAOU-228A-GR-120-S, TJAOU-228A-GR-123-S, TJAOU-228A-GR-123-DU, TJAOU-228A-GR-129-S, TJAOU-228A-GR-161-S, and TJAOU-228A-GR-216-S); all but sample TJAOU-228A-GR-216-S were estimated values. Methylene chloride was not detected in the duplicate sample TJAOU-228A-GR-161-DU. Two trip blanks and one equipment blank yielded levels above the minimum detection limit (MDL) but below the practical

quantitation limit (PQL) (TJAOU-228A-TB sampled December 1, 1998, and December 2, 1998, and TJAOU-228A-EB sampled December 1, 1998). Methylene chloride was also detected above the MDL but below the PQL in one soil pile sample (TJAOU-228A-GR-221-S). Table 3.4.5-10 summarizes the VOCs analyzed and the associated MDLs used for off-site analyses.

SVOCs

Tables 3.4.5-11 and 3.4.5-12 summarize the off-site SVOC analytical results for the results for both the site-confirmatory sampling (19 surface soil samples, 1 subsurface soil sample, 8 duplicate samples, and 5 equipment blank samples) and the soil piles sampling (6 surface soil samples and 1 duplicate sample).

Because there are no established background concentrations for SVOC compounds in soil, any detectable SVOCs in the samples collected at SWMU 228A were considered an indication of contamination. Fifteen different SVOCs were detected in some of the confirmatory samples from SWMU 228A: acenaphthene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(ghi)perylene, benzo(k)fluoranthene, chrysene, di-n-butyl phthalate, bis(2-ethylhexyl)phthalate, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, phenanthrene, and pyrene. With the exceptions of benzo(b)fluoranthene, chrysene, fluoranthene, phenanthrene, and pyrene, the detected SVOCs were estimated 'J' values greater than or equal to the MDL but less than the PQL for all the site-confirmatory samples. For all soil pile samples, the detected SVOCs were estimated 'J' values greater than or equal to the MDL but less than the PQL. None of the SVOCs exceeded 1 part per million. Table 3.4.5-13 summarizes the SVOCs analyzed and the associated MDLs used for off-site analyses.

Radionuclides

Tables 3.4.5-14 and 3.4.5-15 summarize the off-site and on-site gamma spectroscopy analysis results for both the site-confirmatory sampling (127 surface soil samples, 4 subsurface soil samples, 16 duplicate samples, and 6 equipment blanks) and the soil piles sampling (25 surface soil samples and 2 duplicate samples), respectively. Tables 3.4.5-16 and 3.4.5-17 summarize the off-site isotopic uranium (alpha spectroscopy) analysis results for both the site-confirmatory sampling (36 surface soil samples, 1 subsurface soil sample, 8 duplicate samples, 4 equipment blanks, and 1 trip blank) and the soil piles sampling (10 surface soil samples and 1 duplicate sample). Thorium-232 and cesium-237 were not detected at levels above the background activity limit in any of the confirmatory samples. Uranium-235 and uranium-238 were detected at levels above the background activity limit in many of the site-confirmatory surface soil samples and soil pile samples. Uranium-238 was detected at a level slightly above the background activity limit in one site-confirmatory subsurface soil sample. Uranium-233/234 was not detected above the background activity limit in any of the site-confirmatory samples but was detected in one soil pile sample.

Soil sample TJAOU-228A-GR-123-S yielded the highest uranium-238 activity at 11.4 pCi/g. However, the duplicate sample TJAOU-228A-GR-123-DU and the on-site split sample TJAOU-228A-GR-123-S yielded uranium-238 activities of 2.2 and 0.884 pCi/g, respectively. These two lower values are more reasonable because location GR-123 is situated in an area

that had no DU fragments or weapons debris. All of the uranium-238 values were well below the PRG of 271 pCi/g set forth in the VCM plan (SNL/NM July 1998).

Data Quality

Tables 3.4.5-5, 3.4.5-8, 3.4.5-11, 3.4.5-14, and 3.4.5-16 show the results of the analyses of metals, VOC, SVOC, and radionuclide QA/QC samples that were collected during the confirmatory sampling at SWMU 228A. These QA/QC samples consisted of six equipment blanks and four trip blanks. All of the equipment blanks and trip blanks were analyzed off site for metals, VOCs, and SVOCs. For radionuclides, one of the equipment blanks was analyzed on site and all other blanks were analyzed off site.

The QA/QC samples for metals yielded either no detections or extremely low estimated values. To assess the precision of laboratory analytical procedures, nine samples were collected and analyzed for metals in replicate. Relative percent differences (RPD) were calculated from the data and are included in Table 3.4.5-18. Because many of the sample pairs are nondetect, RPDs could not be calculated for cadmium, mercury, or silver.

The RPDs range from 0 to 24.3 percent for arsenic, 0.9 to 25.8 for barium, 3.3 to 35.7 for chromium, 0.1 to 26.2 for lead, 7.3 to 57.9 for selenium, and 44.7 to 49.9 for uranium. In general, the results obtained for the sample duplicates are in satisfactory agreement for a soil matrix.

None of the QA/QC samples for VOCs yielded detectable levels of benzene, although three of the samples (one equipment blank and two trip blanks) yielded estimated values of methylene chloride that were above the MDL and below the PQL. Methylene chloride is a common analytical laboratory contaminant (Bleyler February 1988). No SVOCs were detected in any of the QA/QC samples. The on-site QA/QC sample for radionuclides yielded no detections. The off-site QA/QC samples for radionuclides yielded detections in one or more of the samples.

Data Validation

All off-site laboratory results were reviewed and verified/validated according to SNL/NM (July 1994). In addition, all gamma spectroscopy results were reviewed according to SNL/NM (July 1996). Annex 3-F contains summaries of the off-site data validation results. The verification/validation process confirmed that the data are acceptable for use in this NFA proposal for SWMU 228A.

3.5 Site Conceptual Model

The site conceptual model for SWMU 228A is based upon the residual COCs identified in soil samples from the surface and subsurface of the Centrifuge Dump Site following the VCM remedial activities. Residual COCs identified in samples from soil piles generated during VCM remediation activities also contribute to the site conceptual model for SWMU 228A. This section summarizes the nature and extent of contamination and the environmental fate of COCs.

Table 3.4.5-18
Summary of SWMU 228A Field Duplicate Relative Percent Differences
(Off-Site Laboratories)

Sample Attributes			Relative Percent Difference								
Record Number ^a	ER Sample ID (Figure 3.4.5-8)	Sample Depth (ft)	Arsenic	Barium	Cadmium	Chromium	Lead	Mercury	Selenium	Silver	Uranium
600799	TJAOU-228A-GR-123-S TJAOU-228A-GR-123-DU	0-0.5	5.0	16.1	NC	12.8	12.7	NC	NC	NC	44.7
600835	TJAOU-228A-GR-133-S TJAOU-228A-GR-133-DU	0-0.5	2.9	14.6	NC	14.3	NC	NC	NC	NC	49.9
601188	TJAOU-228A-GR-161-S TJAOU-228A-GR-161-DU	0-0.5	17.2	18.3	NC	33.3	18.1	NC	57.9	NC	NC
601189	TJAOU-228A-GR-171-S TJAOU-228A-GR-171-DU	0-0.5	9.5	1.6	NC	35.7	13.0	NC	7.3	NC	NC
601190	TJAOU-228A-GR-181-S TJAOU-228A-GR-181-DU	0-0.5	22.1	0.9	NC	11.6	0.1	NC	NC	NC	NC
601191	TJAOU-228A-GR-191-S TJAOU-228A-GR-191-DU	0-0.5	3.4	1.0	NC	11.6	5.7	NC	NC	NC	NC
601192	TJAOU-228A-GR-201-S TJAOU-228A-GR-201-DU	0-0.5	0.0	10.6	NC	3.3	4.6	NC	NC	NC	NC
601192	TJAOU-228A-GR-211-S TJAOU-228A-GR-211-DU	0-0.5	15.8	2.6	NC	25.6	2.6	NC	NC	NC	NC
601212	TJAOU-228A-GR-221-S TJAOU-228A-GR-221-DU	0-0.5	24.3	25.8	NC	10.5	26.2	NC	NC	NC	NC

^a Analysis request/chain of custody.

DU = Duplicate sample.

ER = Environmental Restoration.

ft = Foot (feet).

GR = Grab sample.

ID = Identification.

NC = Not calculated for estimated values or nondetected results.

S = Soil sample.

SWMU = Solid Waste Management Unit.

TJAOU = Tijeras Arroyo Operable Unit.

3.5.1 Nature and Extent of Contamination

The COCs at SWMU 228A were DU, metals, VOCs, SVOCs, and HE associated with construction debris and DU-contaminated weapons debris that had been dumped at the site in the 1950s (Section 3.2). No HE compounds were detected at SWMU 228A. Because background concentrations for VOCs and SVOCs were not applicable, any detectable VOCs or SVOCs were considered potential contamination. Two VOC and 15 SVOC compounds (11 of which were estimated) were detected in a few samples (Section 3.4.5).

Metal and radionuclide COCs were determined by comparing sample results to background concentrations and activities that had been established for the surface soils in the North Supergroup Area (Dinwiddie September 1997). Any metals or radionuclides found to exceed background in any sample were considered potential COCs for the site. Consequently, metal COCs included barium, cadmium, lead, mercury, selenium, and silver. The radiological COCs include uranium-235 and uranium-238. Table 3.5.1-1 summarizes the COCs for SWMU 228A.

The confirmatory soil samples were collected to a maximum depth of 3 feet. Extensive sampling at other depths was not deemed important primarily because the VCM removed all DU fragments and debris from the site and confirmatory surveys (visual, geophysical, and radiological) did not identify any remaining remediation targets. Additionally, the vertical rate of contamination migration was expected to be extremely low for SWMU 228A because of the low precipitation, high evapotranspiration, impermeable vadose zone soils, and the relatively low solubility of DU and metals. Therefore, the confirmatory soil samples are considered to be representative of the soil potentially contaminated with COCs and sufficient to determine the vertical extent, if any, of COCs.

Radionuclide and metal COCs exceeded background activities or concentrations in numerous surface soil samples and one subsurface soil sample. With the exception of methylene chloride in one subsurface sample, VOCs and SVOCs were detected only in surface soil samples. The horizontal extent of residual contamination is limited to areas known to have contained DU fragments and/or other debris. Thus, the areas with residual contamination occur sporadically with no particular COC associations or correlation to other locations or areas that could be delineated as contaminated.

3.5.2 Environmental Fate

The primary source of COCs for SWMU 228A was the disposal of construction debris and DU-contaminated weapons debris at the site in the 1950s. The primary release mechanism of COCs to the surface and subsurface soils is the degradation of debris that occurred prior to debris removal during the VCM.

After the removal of weapons and construction debris, possible secondary release mechanisms include suspension and/or dissolution of trace levels of residual COCs in surface-water runoff and percolation to the vadose zone, direct contact with soil (radionuclides only), dust emissions, and uptake of COCs in the soil by biota (Figure 3.5.2-1). The depth to groundwater at the site (at approximately 280 feet bgs) precludes migration of residual COCs to the shallow groundwater system. The pathways to receptors are soil ingestion, inhalation, and direct exposure (radionuclides). Plant uptake was also considered as a pathway for the residential scenario only. Annex 3-1 provides additional discussion of the fate and transport of COCs at SWMU 228A.

Table 3.5.1-1
Summary of Residual COCs for SWMU 228A

COC Type	Number of Samples	COCs Greater Than Background	Maximum Background Limit/North Supergroup ^a (mg/kg except where noted)	Maximum Concentration (mg/kg except where noted)	Average Concentration ^b (mg/kg except where noted)	Sampling Locations Where Background Concentration Exceeded ^c
Metals	59 environmental; 9 duplicates	Arsenic	4.4	3.32	2.40	None
		Barium	200	216	125	TJAOU-228A-GR-133-S TJAOU-228A-GR-140-S TJAOU-228A-GR-144-S
		Cadmium	<1	1.77	0.22	TJAOU-228A-GR-129-S TJAOU-228A-GR-209-S
		Chromium	12.8	12.0	7.5	None
		Lead	11.2	40.5	9.7	TJAOU-228A-GR-129-S TJAOU-228A-GR-133-S TJAOU-228A-GR-140-S TJAOU-228A-GR-143-S TJAOU-228A-GR-144-S TJAOU-228A-GR-147-S TJAOU-228A-GR-148-S TJAOU-228A-GR-163-S TJAOU-228A-GR-209-S
		Mercury	<0.1	0.063 J	0.014	All samples below nonquantified background value
		Selenium	<1	0.918	0.304	All samples below nonquantified background value
		Silver	<1	0.436 J	0.152	All samples below nonquantified background value
		Uranium	2.3	83.9	28.5	All samples above background value
		Cs-137	0.836 pCi/g	0.621 pCi/g	Not calculated ^d	None
Radionuclides	20 environmental; 2 duplicates	Th-232	1.54 pCi/g	1.24 pCi/g	Not calculated ^d	None
	121 environmental; 18 duplicates; 35 splits	U-233/234	1.6 pCi/g	1.64 pCi/g	Not calculated ^d	TJAOU-228A-GR-149-S
	121 environmental; 18 duplicates; 35 splits	U-235	0.18 pCi/g	0.8 pCi/g	Not calculated ^d	47 samples above background level, plus an additional 28 samples with nondetect results where the MDA exceeds background
	47 environmental; 9 duplicates	U-238	1.3 pCi/g	11.4 pCi/g	Not calculated ^d	123 samples above background level
	168 environmental; 27 duplicates; 35 splits					
	168 environmental; 27 duplicates; 35 splits					

Refer to footnotes at end of table.

Table 3.5.1-1 (Continued)
Summary of COCs for SWMU 228A

COC Type	Number of Samples 26 environmental; 9 duplicates	COCs Greater Than Background	Maximum Background Limit/North Supergroup ^a (mg/kg except where noted)	Maximum Concentration (mg/kg except where noted)	Average Concentration ^b (mg/kg except where noted)	Sampling Locations Where Background Concentration Exceeded ^c
Volatile Organic Compounds		Benzene	NA	1.2 µg/kg	0.51 µg/kg	TJAOU-228A-GR-133-S
		Methylene chloride	NA	7.2 µg/kg	0.72 µg/kg	TJAOU-228A-GR-120-S TJAOU-228A-GR-123-S TJAOU-228A-GR-123-DU TJAOU-228A-GR-129-S TJAOU-228A-GR-161-S TJAOU-228A-GR-216-S TJAOU-228A-GR-221-S
Semivolatile Organic Compounds	26 environmental; 9 duplicates	Acenaphthene	NA	70 J µg/kg	15 µg/kg	TJAOU-228A-GR-129-S
		Anthracene	NA	110 J µg/kg	23 µg/kg	TJAOU-228A-GR-129-S TJAOU-228A-GR-133-S TJAOU-228A-GR-133-DU TJAOU-228A-GR-140-S TJAOU-228A-GR-147-S TJAOU-228A-GR-171-DU
		Benzo(a)anthracene	NA	320 J µg/kg	59 µg/kg	TJAOU-228A-GR-123-S TJAOU-228A-GR-123-DU TJAOU-228A-GR-129-S TJAOU-228A-GR-133-S TJAOU-228A-GR-133-DU TJAOU-228A-GR-140-S TJAOU-228A-GR-145-S TJAOU-228A-GR-147-S TJAOU-228A-GR-149-S TJAOU-228A-GR-171-DU TJAOU-228A-GR-186-S
		Benzo(a)pyrene	NA	260 J µg/kg	47 µg/kg	TJAOU-228A-GR-123-DU TJAOU-228A-GR-129-S TJAOU-228A-GR-133-S TJAOU-228A-GR-133-DU TJAOU-228A-GR-140-S TJAOU-228A-GR-145-S TJAOU-228A-GR-147-S TJAOU-228A-GR-149-S TJAOU-228A-GR-171-DU TJAOU-228A-GR-171-DU

Refer to footnotes at end of table.

Table 3.5.1-1 (Continued)
Summary of COCs for SWMU 228A

COC Type	Number of Samples	COCs Greater Than Background	Maximum Background Limit/North Supergroup ^a (mg/kg except where noted)	Maximum Concentration (mg/kg except where noted)	Average Concentration ^b (mg/kg except where noted)	Sampling Locations Where Background Concentration Exceeded ^c
Semivolatile Organic Compounds (Continued)		Benzo(b)fluoranthene	NA	370 µg/kg	65 µg/kg	TJAOU-228A-GR-123-DU TJAOU-228A-GR-129-S TJAOU-228A-GR-133-S TJAOU-228A-GR-133-DU
						TJAOU-228A-GR-140-S TJAOU-228A-GR-140-S TJAOU-228A-GR-145-S TJAOU-228A-GR-149-S
						TJAOU-228A-GR-171-DU TJAOU-228A-GR-186-S
		Benzo(ghi)perylene	NA	250 J µg/kg	42 µg/kg	TJAOU-228A-GR-133-S TJAOU-228A-GR-133-DU
						TJAOU-228A-GR-140-S TJAOU-228A-GR-147-S
		Benzo(k)fluoranthene	NA	280 J µg/kg	33 µg/kg	TJAOU-228A-GR-171-DU TJAOU-228A-GR-133-S
						TJAOU-228A-GR-133-DU TJAOU-228A-GR-140-S
		Chrysene	NA	370 µg/kg	66 µg/kg	TJAOU-228A-GR-149-S TJAOU-228A-GR-123-S TJAOU-228A-GR-123-DU
						TJAOU-228A-GR-129-S TJAOU-228A-GR-133-S
						TJAOU-228A-GR-133-DU TJAOU-228A-GR-140-S
						TJAOU-228A-GR-145-S TJAOU-228A-GR-147-S
						TJAOU-228A-GR-149-S TJAOU-228A-GR-171-DU
						TJAOU-228A-GR-186-S
		Di-n-butylphthalate	NA	60 J µg/kg	15 µg/kg	TJAOU-228A-GR-120-S TJAOU-228A-GR-123-S
						TJAOU-228A-GR-129-S TJAOU-228A-GR-147-S

Refer to footnotes at end of table.

Table 3.5.1-1 (Continued)
Summary of COCs for SWMU 228A

COC Type	Number of Samples	COCs Greater Than Background	Maximum Background Limit/North Supergroup ^a (mg/kg except where noted)	Maximum Concentration (mg/kg except where noted)	Average Concentration ^b (mg/kg except where noted)	Sampling Locations Where Background Concentration Exceeded ^c
Semivolatile Organic Compounds (Continued)		Bis(2-ethylhexyl) phthalate	NA	110 J µg/kg	24 µg/kg	TJAOU-228A-GR-120-S TJAOU-228A-GR-123-S TJAOU-228A-GR-123-DU TJAOU-228A-GR-133-S TJAOU-228A-GR-133-DU TJAOU-228A-GR-137-S TJAOU-228A-GR-140-S TJAOU-228A-GR-143-S TJAOU-228A-GR-145-S TJAOU-228A-GR-147-S TJAOU-228A-GR-149-S
		Fluoranthene	NA	630 µg/kg	112 µg/kg	TJAOU-228A-GR-123-S TJAOU-228A-GR-123-DU TJAOU-228A-GR-129-S TJAOU-228A-GR-133-S TJAOU-228A-GR-133-DU TJAOU-228A-GR-140-S TJAOU-228A-GR-145-S TJAOU-228A-GR-147-S TJAOU-228A-GR-149-S TJAOU-228A-GR-171-DU TJAOU-228A-GR-181-DU TJAOU-228A-GR-186-S TJAOU-228A-GR-221-S
		Fluorene	NA	50 J µg/kg	12 µg/kg	TJAOU-228A-GR-129-S
		Ideno(1,2,3-c,d) pyrene	NA	99 J µg/kg	21 µg/kg	TJAOU-228A-GR-133-S TJAOU-228A-GR-140-S TJAOU-228A-GR-147-S TJAOU-228A-GR-171-DU

Refer to footnotes at end of table.

Table 3.5.1-1 (Continued)
Summary of COCs for SWMU 228A

COC Type	Number of Samples	COCs Greater Than Background	Maximum Background Limit/North Supergroup ^a (mg/kg except where noted)	Maximum Concentration (mg/kg except where noted)	Average Concentration ^b (mg/kg except where noted)	Sampling Locations Where Background Concentration Exceeded ^c
Semivolatile Organic Compounds (Continued)		Phenanthrene	NA	420 µg/kg	51 µg/kg	TJAOU-228A-GR-123-S
						TJAOU-228A-GR-123-DU
						TJAOU-228A-GR-129-S
						TJAOU-228A-GR-133-S
						TJAOU-228A-GR-133-DU
						TJAOU-228A-GR-140-S
						TJAOU-228A-GR-145-S
						TJAOU-228A-GR-147-S
						TJAOU-228A-GR-149-S
						TJAOU-228A-GR-171-DU
		Pyrene	NA	600 µg/kg	109 µg/kg	TJAOU-228A-GR-120-S
						TJAOU-228A-GR-123-S
						TJAOU-228A-GR-123-DU
						TJAOU-228A-GR-129-S
						TJAOU-228A-GR-133-S
						TJAOU-228A-GR-133-DU
						TJAOU-228A-GR-140-S
						TJAOU-228A-GR-145-S
						TJAOU-228A-GR-147-S
						TJAOU-228A-GR-149-S
						TJAOU-228A-GR-171-DU
						TJAOU-228A-GR-186-S

^aFrom Dinwiddle September 1997.

^bAverage concentration includes all samples. For nondetectable results, the detection limit is used to calculate the average.

^cIncludes all samples with detectable concentrations (VOCs and SVOCs) or all samples with nondetectable results where the MDA exceeds background (radionuclides).

^dAn average MDA is not calculated because of the variability in instrument counting error and the number of reported nondetectable activities.

COC = Constituent of concern.

DU = Duplicate sample.

GR = Grab sample.

J = The reported value is greater than or equal to the method detection limit, but is less than the practical quantitation limit.

µg/kg = Microgram(s) per kilogram.

MDA = Minimum detectable activity.

mg/kg = Milligrams per kilogram.

NA = Not applicable.

pCi/g = Picocurie(s) per gram.

S = Soil sample.

SVOC = Semivolatile organic compounds.

SWMU = Solid Waste Management Unit.

TJAOU = Tijeras Arroyo Operable Unit.

VOC = Volatile organic compounds.

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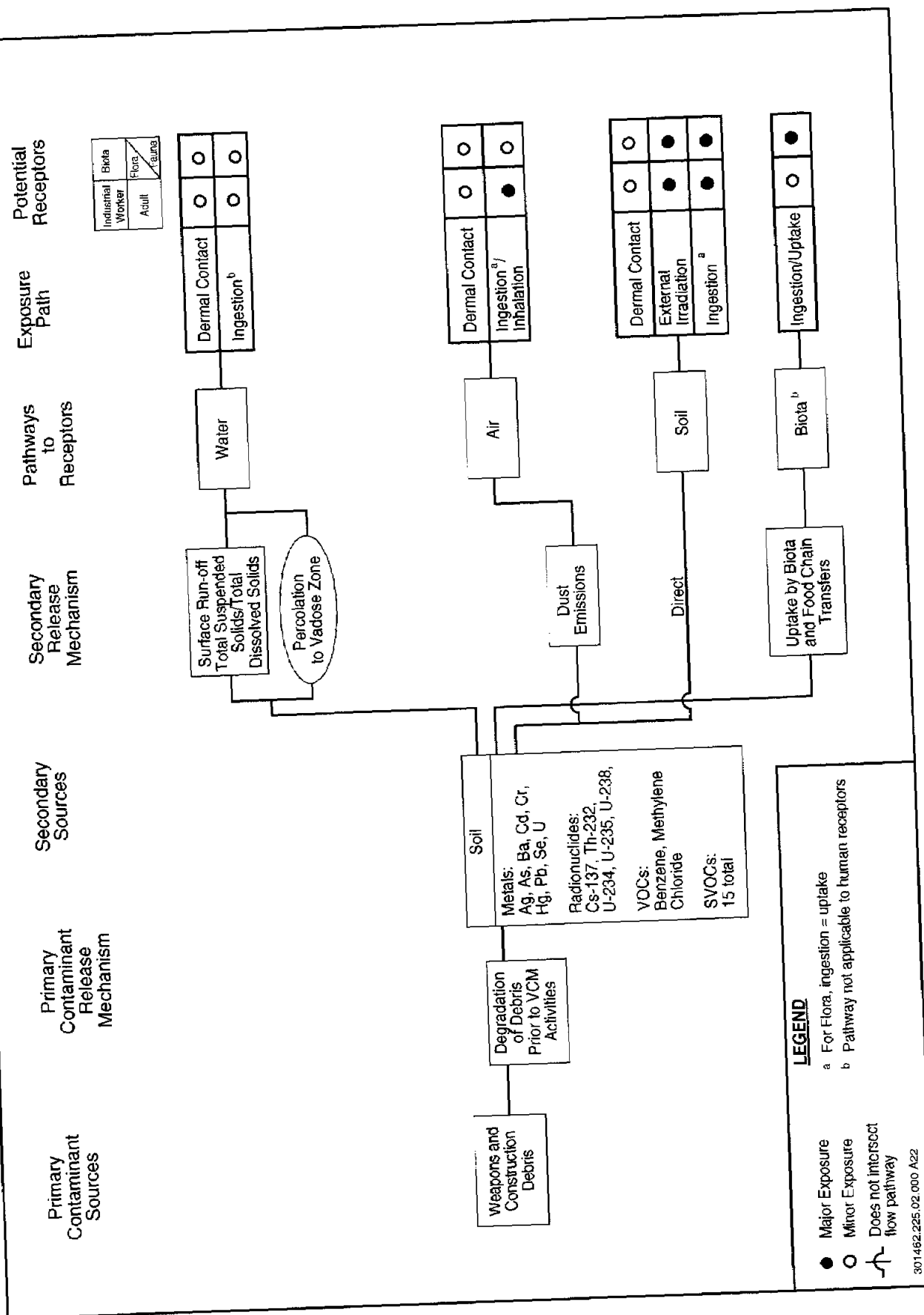


Figure 3.5.2-1
Conceptual Model Flow Diagram for SWMU 228A, Centrifuge Dump Site



Table 3.5.1-1 summarizes residual COCs for SWMU 228A. Based upon the nature and extent of contamination at the site (Section 3.5.1), metals, VOCs, SVOCs, and radionuclide COCs occur sporadically at low concentrations in the surface soils, generally at areas known to have contained visible DU fragments and/or other debris. Other than this, no distinct vertical or horizontal distribution of contamination is present. All potential COCs were retained in the conceptual model and were evaluated in the human health and ecological risk assessments.

The current land use for SWMU 228A is industrial. The future land use for SWMU 228A is also industrial (DOE et al. September 1995). The potential human receptor is considered an industrial worker at the site. For all applicable pathways, the exposure route for the industrial worker is dermal contact and ingestion/inhalation. Major exposure routes modeled in the human health risk assessment include soil ingestion for nonradiological and radiological COCs and direct gamma exposure for the radiological COCs. The inhalation pathway for both nonradiological and radiological COCs is also included because of the potential to inhale dust and volatiles (volatile inhalation for nonradiologicals only). Soil ingestion is included for the radiological COCs, as well. Only soil ingestion is considered a primary contributor to exposure for the industrial worker. Potential biota receptors include flora and fauna at the site. Direct soil ingestion is considered a major exposure route for biota, in addition to ingesting COCs through food chain transfers, the direct contact with COCs in soil, and direct gamma exposure from radiological COCs. Section V, Annex 3-I provides additional discussion of the exposure routes and receptors at SWMU 228A.

3.6 Site Assessments

Site assessment at SWMU 228A includes risk screening assessments followed by risk baseline assessments (as required) for both human health and ecological risk. This section briefly summarizes the site assessment results, and Annex 3-I provides details of the site assessment.

3.6.1 Summary

The site assessment concludes that SWMU 228A has no significant potential to affect human health under the industrial land-use scenario recommended by DOE et al. (October 1995). After considering the uncertainties associated with the available data and modeling assumptions, ecological risks associated with SWMU 228A were found to be very low. Section 3.6.2 briefly describes and Annex 3-I provides details of the site assessments.

3.6.2 Screening Assessments

Risk screening assessments were performed for both human health risk and ecological risk for SWMU 228A. This section summarizes the results.

3.6.2.1 Human Health

SWMU 228A has been recommended for industrial land-use (DOE et al. September 1995). Annex 3-I provides a complete discussion of the risk assessment process, results, and uncertainties. Because of the presence of COCs in concentrations or activities greater than

background levels, it was necessary to perform a health risk assessment analysis for the site. This assessment included metals and radionuclide COCs detected above background and any organic compounds detected above their detection limits. The risk assessment process provides a quantitative evaluation of the potential adverse human health effects caused by constituents in soil at the site. The Risk Screening Assessment Report calculated the hazard index (HI) and excess cancer risk for an industrial land-use setting. The excess cancer risk from nonradiological COCs and the radiological COCs is not additive (EPA 1989).

In summary, the HI calculated for SWMU 228A nonradiological COCs is 0.03 for the industrial land-use setting, which is less than the numerical standard of 1.0 suggested by risk assessment guidance (EPA 1989). Excess cancer risk was estimated at $2\text{E-}6$ for SWMU 228A nonradiological COCs for an industrial land-use setting. Guidance from the NMED indicates that excess lifetime risk of developing cancer by an individual must be less than $1\text{E-}6$ for Class A and B carcinogens and less than $1\text{E-}5$ for Class C carcinogens (NMED March 1998). For this risk assessment, the excess cancer risk was driven by benzo(a)pyrene, benzo(b)fluoranthene, and benzo(g,h,i)perylene. All three of these organics are Class B2 carcinogens. Thus, the excess cancer risk for SWMU 228A was above the suggested acceptable risk value of $1\text{E-}6$. Incremental risk was determined by subtracting risk associated with background from potential COC risk. The incremental HI is 0.03. Incremental cancer risk was $1.52\text{E-}6$ for the industrial land-use scenario, a value above the proposed guidelines.

The calculated HI for the nonradiological COCs was within the human health acceptable range for the industrial land-use scenario compared to established numerical guidance. Although the excess cancer risk was above proposed guidelines, the excess cancer risk was conservatively estimated by using maximum concentrations of the detected COCs. Because the site was adequately characterized, average concentrations were more representative of actual site conditions. If the 95th upper confidence limit of the mean for benzo(a) pyrene (0.13 mg/kg), benzo(b) fluoranthene (0.18 mg/kg), and benzo(g,h,i) perylene (0.11 mg/kg) are used in place of maximum concentrations, the excess cancer risk is reduced to $8\text{E-}7$ which is within proposed guidelines considering an industrial land-use scenario.

The incremental total effective dose equivalent for radionuclides for an industrial land-use setting for SWMU 228A is $7.0\text{E-}1$ millirems (mrem)/year (yr), which is significantly less than the recommended dose limit of 15 mrem/yr found in EPA (August 1997) reflected in SNL/NM (February 1998b).

The residential land-use scenarios for this site are provided only for comparison in the Risk Screening Assessment Report (Annex 3-I). The report concludes that SWMU 228A does not have potential to affect human health under a residential land-use scenario.

A close examination of the exposure assumptions revealed an overestimation of risk from nonradiological COCs, primarily attributable to the use of maximum exposure concentrations. Based upon an evaluation of this uncertainty, human health risks associated with this site are expected to be within the proposed guidelines and do not have the potential to affect human health under an industrial land-use scenario (see Sections VI.8 and VI.9, Annex 3-I).

3.6.2.2 Ecological

An ecological screening assessment that corresponds with the screening procedures in the EPA's Ecological Risk Assessment Guidance for Superfund (EPA 1997) was performed as set forth by the NMED Risk-Based Decision Tree (NMED March 1998). An early step in the evaluation is comparing COC concentrations to background and identifying potentially bioaccumulative constituents (see Annex 3-I, Sections V, VII.2, and VII.3). This methodology also requires that a site conceptual model and a food web model be developed and that ecological receptors be selected. Each of these items is presented in IT (July 1998) and will not be duplicated here. The screening also includes the estimation of exposure and ecological risk.

Annex 3-I presents the results of the ecological risk assessment screen. Site-specific information was incorporated into the screening assessment when such data were available. Hazard quotients greater than unity were initially predicted for uranium, barium and a number of organic compounds. A close examination of the exposure assumptions revealed an overestimation of risk, primarily attributable to treatment of exposure concentration, conservative exposure modeling assumptions, and conservative toxicity benchmark values. Based upon an evaluation of these uncertainties, ecological risks associated with this site are expected to be low.

3.7 No Further Action Proposal

Based upon field investigation data and the human-health risk assessment analysis, an NFA decision is being recommended for SWMU 228A for the following reasons:

- The VCM remediation has removed the DU fragments, weapon debris, and construction debris.
- The soil has been sampled for all relevant COCs.
- No residual nonradiological or radiological COCs are present in soil at levels considered hazardous to human health for an industrial land-use scenario.
- None of the nonradiological or radiological constituents warrant ecological concern.

Based upon the evidence provided above, SWMU 228A is proposed for NFA according to Criterion 5 (NMED March 1998).

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ANNEX 3-C
Segmented Gate System
ER Site 228A Remediation Project
Thermo NUtech (December 15, 1998)

THERMO NUTECH

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SEGMENTED GATE SYSTEM ER SITE 228A REMEDIATION PROJECT

SANDIA NATIONAL LABORATORIES

Final Report

December 15, 1998



A Subsidiary of Thermo TerraTech, Inc.,
a Thermo Electron Company

SUMMARY

Thermo NUtech conducted a radioactive material volume reduction project for Sandia National Laboratories (Contract Number BC-0276) at ER Site 228A located east of TA-II complex on the northern rim of the arroyo. The goal of the project was to reduce the volume of contaminated soil that would require off-site storage and disposal. The soil at the site was contaminated with depleted uranium (DU).

The Thermo NUtech Segmented Gate System (SGS) was mobilized to ER Site 228A on November 2, 1998, to an area that had been previously prepared by Thermo NUtech personnel in August 1998. Excavation and pre-screening of the soil to remove the large debris was accomplished in August. Assembly and calibration were accomplished over a four-day period. Soil processing began on Friday, November 6, 1998. Soil was processed from November 6th through November 17th, with actual processing taking place on 11 of those days. A total of 49.18 hours of processing time were logged.

A total of 1,352 cubic yards were processed through the SGS. Total volume reduction reported by the SGS was 99.56 percent. Actual volume reduction for the first pass was still in excess of 99 percent after accounting for the volume of soil that was sent to the above-criteria path due to unscheduled operational halts. Total volume of the above-criteria soil pile was 4.68 cubic yards diverted by SGS between November 6–17 plus approximately 11.68 cubic yards due to unscheduled halts. The approximately 16 cubic yards in the above-criteria pile was processed again on November 17 to remove the soil generated from unscheduled operational halts, and resulted in approximately 5 cubic yards of above-criteria soil (contents of 21 55-gallon drums) requiring off-site disposal. An estimated 5.9 percent volume (or 80 cubic yards: 10 cubic yards in August pre-screening, and 70 cubic yards during SGS processing) in oversize material, was not sorted through the SGS.

Demobilization of the system was completed on November 24, 1998 when the equipment was shipped to the Thermo NUtech Laboratory Facility at 7021 Pan American HWY NE, Albuquerque, NM.

Total cost of SGS operations at Sandia National Laboratories was \$220,040 including \$29,400 for excavation and pre-screening, \$41,300 for mobilization, \$117,000 for operations and \$32,340 for demobilization.



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SECTION 1

1.0 SITE INFORMATION

1.1 GENERAL

This report provides the results of Thermo NUtech's soil remediation project for the DU contaminated soil at the Sandia National Laboratories using the Segmented Gate System (SGS). Thermo NUtech performed this work as a subcontractor to Sandia National Laboratories (SNL) as a contaminated soil volume reduction project in the remediation of Environmental Restoration (ER) Site 228A.

1.2 SITE BACKGROUND

Environmental Restoration Site 228A, the Centrifuge Dump Site and Tijeras Arroyo Operative Unit-ADS 1309, is located about 500 ft east of Technical Area II (TA-II). This site is on the northern rim of Tijeras Arroyo within the boundaries of Kirtland Air Force Base immediately southwest of Albuquerque, New Mexico. In July 1997 heavy rains eroded a portion of a depleted-uranium burial from the Tijeras Arroyo rim. Depleted uranium mixed with soil and some debris washed down the slope creating an alluvial fan deposit that extended as far as 300 feet from its original source.

1.3 SITE CHARACTERISTICS

Characterization of the site indicated that depleted uranium was the only contaminant present at the site. The volume of possibly contaminated soil was estimated at around 1800 cubic yards, including an estimated 20 percent of oversize material. This soil was excavated from 4 tenths of an acre from the arroyo side and bottom, followed by the removal of the larger debris elements using a pre-screen. Characterization of the site included the removal by hand of visible depleted uranium fragments.

1.4 SITE CONTACTS

Site management is provided by the DOE Albuquerque Operations Office (DOE/AL). The Managing and Operating contractor for SNL is the Sandia Corporation, a subsidiary of Lockheed Martin Corporation. The technical contact for the SNL segmented gate project is Sue Collins at Sandia National Laboratories [(505) 284-2546]].



SECTION 2

2.0 MATRIX AND CONTAMINANT DESCRIPTION

The type of matrix treated by the SGS at ER Site 228A was DU contaminated soil (ex situ) mixed with sands and river rock. Most concrete and metal debris was removed by others for SNL. On November 16, Sandia National Laboratories asked Thermo NUtech to process approximately 5 cubic yards of DU contaminated soil from the SNL Burn Site. The Burn Site soil was similar to that at this site except void of the large oversized rocks.

2.1 NATURE AND EXTENT OF CONTAMINATION

The SGS was designed to separate soils based on the radioactive contaminant content. The only radioactive contaminant found in the characterization of ER Site 228A was depleted uranium. Previous contractors removed the DU burial site in the arroyo rim and water run-off gully. Depleted uranium contamination was estimated to exist in approximately 1,385 cubic yards of soil, based on 4 tenths of an acre to a depth of 2-feet in the fan deposit. Field surveys by Sandia personnel defined the extent of contamination as the excavation progressed.

2.2 MATRIX CHARACTERISTICS AFFECTING TREATMENT COST OR PERFORMANCE

This project did not perform any sieve analysis on the soils to be treated at ER Site 228A. The soil moisture content appeared to be about optimal for SGS processing, and was estimated to be approximately 10% by weight, although actual measurements were not made for moisture content. On one windy day, water was added to the soil for processing and no drying process was used. There were some evening rain showers and some snow on November 9, which didn't cause any problems since the sandy soil drained very well.

The oversize debris and rock was estimated to be 360 cubic yards (20 percent of the volume) requiring pre-screening using a field grizzly. The field grizzly is a vertical bar grate measuring 10-feet on a side, mounted at a 45-degree angle to the plane of the ground surface. The vertical grate spacing was 6-inches center to center, and the bars were made of 2-inch by 1-inch plate steel. The soil was dropped onto the field grizzly directly from excavation, which separated debris with a minimum 6-inch dimension from the soil. Smaller debris and soil passed through the grate, while the larger debris slid down and were deposited in front of the grate. The larger debris were collected and spread out for SNL hand survey later. Actual volumes of oversize material were 10 cubic yards during pre-screening (>6 inches) and 70 cubic yards during SGS processing (>1.5 inches).



Of the debris and rocks that passed through the field grizzly, only round river rocks approximately 3-inches in diameter caused any processing difficulties. This size of rock would occasionally fall between the drag feed chain drive gear and chain, which would jam the chain and halt the flow of soil from the screen plant to the SGS. If this resulted in an emptying of the surge feed bin, the lack of soil on the conveyor would halt the SGS operation.

2.3 TECHNOLOGY DESCRIPTION

The Thermo NUtech Segmented Gate System (SGS) is a combination of sophisticated conveyor systems, radiation detectors and computer controls that remove contaminated soil from a moving feed supply on a conveyor belt. Contaminated soil is diverted by segmented gates to a conveyor belt that deposits the soil on an appropriate ground cloth or other container system for stockpiling and later removal.

Contamination of soils by radionuclides is often heterogeneous. Excavation typically results in significant volumes of clean soil combined with the contaminated soil. The SGS provides a method of separating the clean soil from the contaminated soil based on a criterion supplied by the client.

Thermo NUtech's SGS removes a minimum amount of below-criteria soil with the above-criteria soil, significantly reducing the overall amount of material that requires disposal. The system works by conveying radionuclide-contaminated soil on moving conveyor belts under arrays of sensitive radiation detectors. The moving material is assayed and radioactivity content is logged by computer. The computer then calculates when the elevated activities will reach the end of the conveyor belt and activates the segmented gates to divert the above-criteria soil to a separate conveyor, which deposits the soil on the ground or in a container, where it can be segregated and readied for disposal.

The treatment of contaminated soils using the SGS offers the following advantages:

- the system physically surveys the entire volume of soil to be processed;
- no chemicals or other additives are used; and
- generation of secondary waste is limited to Personnel Protective Equipment (PPE) and decontamination rinse water.

The SGS is primarily a gamma detection system. The two sets of detectors allow for the radiation measurement of two gamma energy regions of interest (ROI). Beta detectors have also been installed on another Department of Energy project and were successfully used under the limited requirements of that application. Prior knowledge of the primary radioactive contaminants is required based on accurate analysis of the soil to be processed. Since the SGS currently sorts soil based on a maximum of two



ROIs, these ROIs must be accurately set for the actual contaminants. Oversize rocks and cobbles cannot be processed by the SGS without pre-crushing.

2.4 SYSTEM SCHEMATIC AND OPERATION

Figure 1 depicts the process flow diagram for the SGS. During system operation, contaminated soil is excavated with standard heavy equipment and relocated to the feed point of the mobile SGS processing plant. Feed soil is screened by the SGS mobile screen/hammermill plant, and all rocks and debris with a minimum dimension greater than approximately 75 percent of the thickness of the soil layer deposited on the main conveyor belt are removed. The soil that passes through the screen/hammermill plant is stored in the feed surge bin, which is a reservoir for soil deposited on the main conveyor belt. A mechanical screed allows soil to flow out onto the conveyor belt in a thickness appropriate for the radioisotope(s) of interest and the soil characteristics.

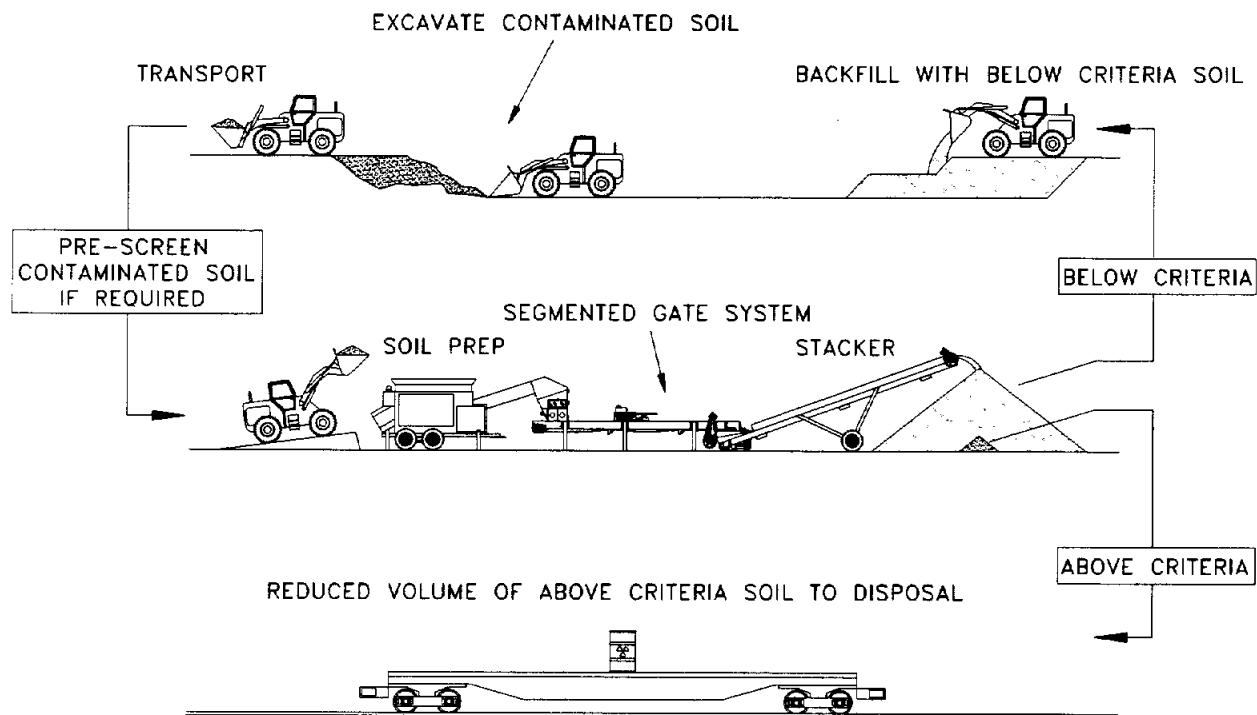


Figure 1. SGS process flow diagram

The soil is then passed under two sets of gamma radiation detector arrays housed in shielded enclosures. The thin detector array is designed for NaI detectors that are 0.160 thick, and incorporates a 0.75-inch poured lead shield fully encased by 3/16-inch thick painted steel. The thick detector array uses NaI detectors with a 2.0-inch thick crystal, and is housed in a similar shield with a 1.0-inch thick poured lead shield. Each detector array spans the width of the belt with two rows of detectors, one row



containing 8 detectors and the other row containing 7 detectors in an offset arrangement. The two detector arrays operate simultaneously.

The process material is conveyed at a pre-selected speed underneath the detector arrays. Counts from the detectors are collected by an on-board computer, which actuates the pneumatic gates based on the analysis of the activity in the soil by several separate computer algorithms. Contaminated material that exceeds the separation criterion for radioactivity is diverted from the normal soil flow stream and deposited by the above-criteria stacking conveyor either in a container or on the ground where it can be packaged for disposal. The below-criteria soil is routed to another stacking conveyor and is piled on the ground, where it may be used to backfill the excavation.

2.5 SYSTEM REQUIREMENTS

The SGS typically requires a footprint of 110 feet by 130 feet, as shown in Figure 2.

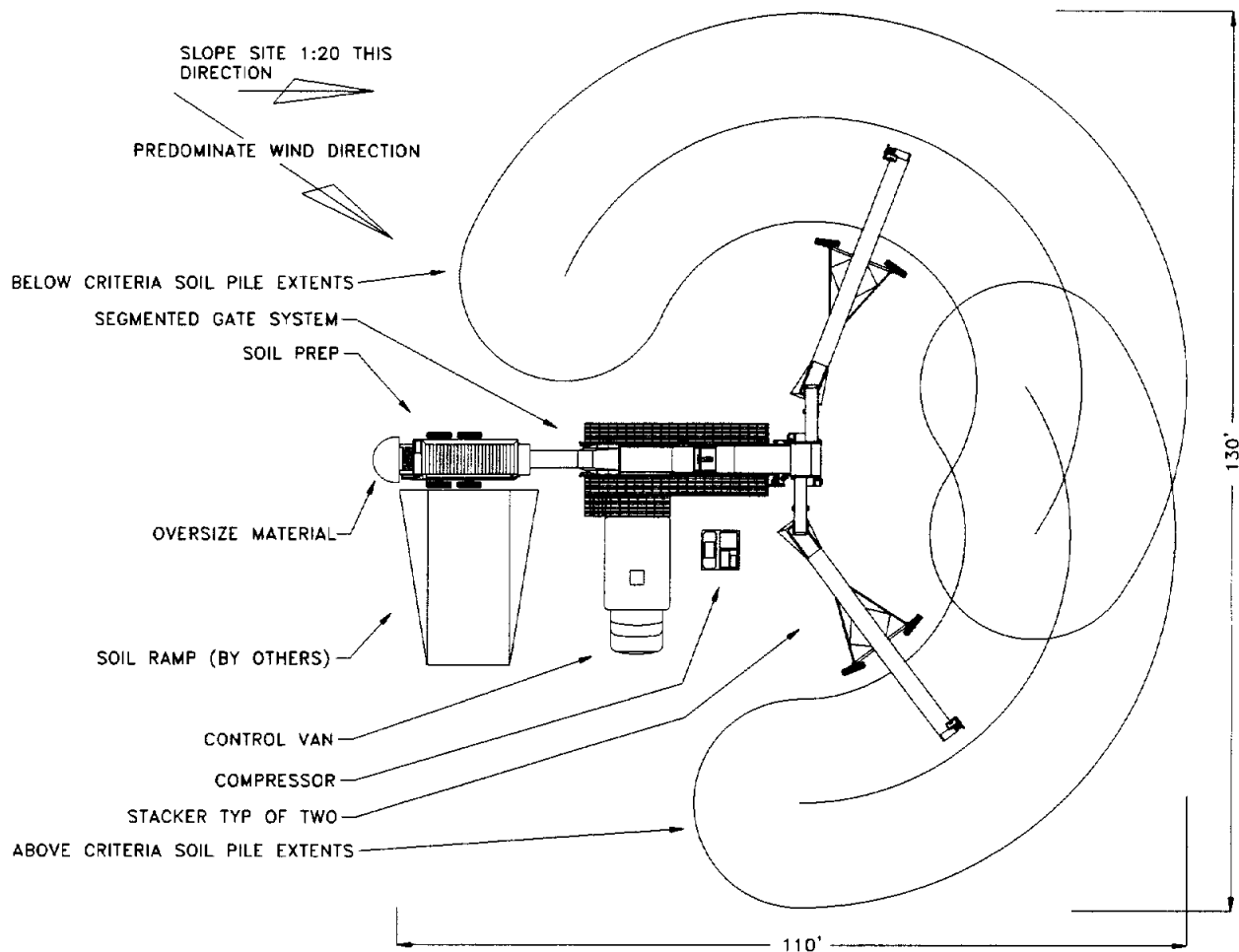
If the radial stacking conveyors are not needed, this footprint may be reduced significantly. The minimum operating surface is a flat dirt pad, free of debris and vegetation. Compaction of the surface is not normally required unless the soil is unusually soft. The screen/hammermill plant is towed into place. The remaining SGS components are removed from the flatbed trucks used to deliver the system and placed in position using a crane with a minimum capacity of 35 tons.

The SGS is completely electrically operated, requiring 208 volts, 3-phase power at approximately 200 amperes. Power can be supplied from site electrical service if available, or using fuel powered electrical generators. The SGS uses a single phase of the 3-phase power to provide any needed 115-volt single-phase service during operational hours. If generators are used, it is usually desirable to have a large generator for operating power, and a small 115-volt generator which is used during non-operating hours to supply power for the environmental control unit to maintain a constant temperature environment for the detectors.

A water source is normally required for the decontamination process. Water may also be required for dust suppression, both for the dirt pad and as an addition to the soil to be processed if necessary.

A local or temporary office building is used for project management and record keeping, as well as for breaks and relief of heat stress or other conditions caused by the local climate. Telephone and fax support are not crucial, but significantly add to the convenience of operations, allowing for the transmission of daily reports, client communications, and support from the corporate office for supplies, repairs, etc. Other required amenities are toilet facilities and a potable water supply.





SEGMENTED GATE SYSTEM FOOTPRINT

Figure 2

Soil is usually delivered to the SGS via a front-end loader. The front-end loader is often also used to excavate the site and to move any accumulated soil piles. Front-end loader operations necessitate the availability of fuel and lubrication services, as do the use of any fuel powered electrical generators.

While health physics support is typically provided by the client, Thermo NUtech can provide senior health physics technicians and full radiation safety support. Personal Protective Equipment (PPE) requirements are determined by the entity providing the radiation safety support, and PPE can be provided by Thermo NUtech or the client as site conditions dictate.



2.6 OPERATING PARAMETERS

The operating parameters for the SGS at ER Site 228A were selected to provide the optimum sensitivity for the contaminant of interest, depleted uranium. The belt speed and soil layer thickness were chosen to maximize production for the sensitivity required to achieve the client specified criteria, which were developed using risk-based calculations for the anticipated future use of the site. The thick detector array was not used during the project. The operating parameters and detector settings are summarized in Tables 1 and 2 below.

Table 1. Operating parameters affecting treatment cost or performance

Parameter	Value or Specification
Processing speed	30 fpm (sorting conveyor belt speed)
Belt length from detectors to conveyor end	Thin array: 16.0 ft (4.88 m) Thick array: 18.0 ft (5.5 m)
Soil layer thickness	2 inches (5.08 cm)
Soil layer width	30.75 inches (78.1 cm)
Soil density (on the conveyor belt)	1.29 g/cm ³
Detector type	Sodium iodide (NaI) 1/16 inch thick crystal

Table 2. SGS detector settings at ER Site 228A

Contaminant	Detector Array	Gamma Energy Region of Interest	Distributed Alarm Setpoint	Multiple Hot Particle Factor
Depleted U	thin	40-110 keV	27 pCi/g	4 (108 pCi/g)

Sandia provided on-site radiation worker safety support. SGS operators were required to wear Level II PPE but were not required to wear respirators.

SECTION 3

3.0 SEGMENTED GATE SYSTEM PERFORMANCE

3.1 PROJECT OBJECTIVES AND APPROACH

The primary objectives of the Segmented Gate System project were:

- Excavate and prepare soil for segmented gate processing;
- Reduce the volume of soil at ER Site 228A requiring off-site disposal;



- Reduce the overall ER Site 228A remediation costs; and
- Provide a basis from which to estimate SGS cost/performance for similar sites projected for future operations.

The SGS was used to sort 1,352 cubic yards of soil suspected of depleted uranium contamination excavated from ER Site 228A at Sandia National Laboratories. The reduction in the volume of contaminated soil was determined based upon the total soil processed versus the amount of soil that was determined to be below the release criteria for the site. The radionuclide activity of the below-criteria soil was compared to the pre-determined risk based release criteria.

3.2 PERFORMANCE SUMMARY

The period of performance for the project demonstration was from July 22, 1998 through November 24, 1998.

Thermo NUtech completed site preparation and soil excavation the first two weeks in August prior to mobilization of the SGS. The SGS was mobilized to the SNL ER Site 228A and arrived on November 2nd. Assembly of the system started while it was being off-loaded. Mobilization and calibration of the system were accomplished by November 6, including detector and operational quality checks. This period also included any SNL site specific training necessary for Thermo NUtech personnel. There were no weather-related delays during the mobilization phase. The SGS was completely operational and ready to process soil on November 6.

A 5-day per week, 10-hour per day schedule was set for processing soil. Soil was processed until November 17, 1998. Work on Saturday and Sunday was allowed based on weather forecast and to ensure completion of soil processing before November 24th. On November 16th, a feasibility study was conducted using 5 cubic yards of soil brought in a dump truck from the SNL Burn Site. The results of that feasibility study are included in the data for ER Site 228A. The system was then decontaminated, surveyed by SNL personnel, loaded onto trucks for transportation to the Thermo NUtech Albuquerque Laboratory on November 24, 1998.

Thermo NUtech personnel using two front-end loaders began the excavation work in August 1998. Excavation included pre-screening of all the soil using a vertical bar field grizzly to remove objects whose minimum dimension was greater than 6 inches. After pre-screening, the soil was stockpiled for processing. The stockpiled soil was identified by SNL personnel as soil pile number 4. The oversize material was spread out in a single layer in preparation for hand survey by SNL personnel. Excavation and pre-screening were completed on August 14th.



Soil was processed using the SGS for 11 days in November. Figure 3 depicts the daily volumes processed.

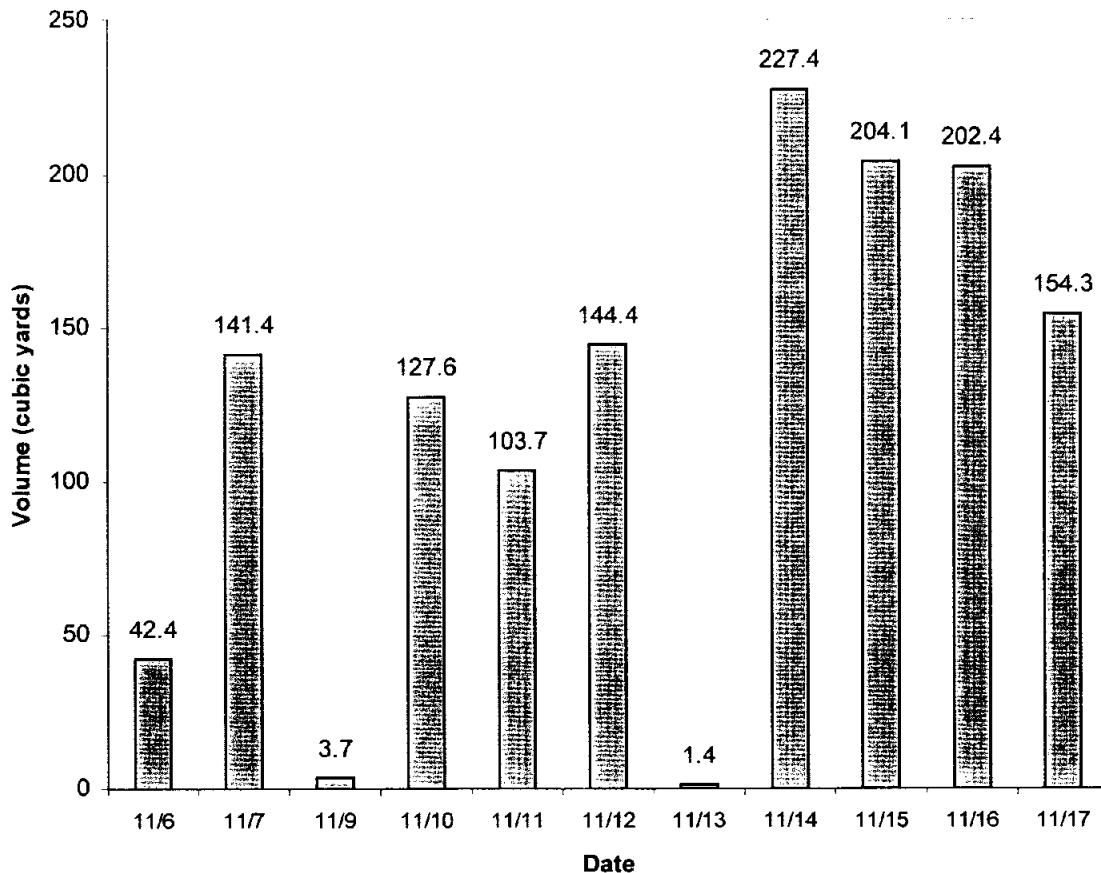


Figure 3. Daily processing volumes

Average daily operational time was 4.47 hours. The average daily operational time was impacted by provisions for a pre-job briefing, snow and wind delay on November 9th, equipment malfunctions due to rocks, concern with radon interference on November 13th, and completion of calibration on November 6th.

An overall volume reduction of 99.56 percent was realized after processing the entire volume of soil including the 5 cubic yards of Burn Site soil and approximately 4.68 cubic yards of above-criteria soil that was reprocessed. This included soil that was diverted for excessive activity (including soil that was diverted due to periodic source checks), and soil that was diverted due to unscheduled pauses in operations. Unscheduled pauses due to soil flow difficulties or other operational problems resulted in approximately 151 kg being diverted each time, with a total unrecorded mass diverted of approximately 11,200 kg (about 11.7 cubic yards). (Number of pauses 74 times 151.2 kg).



On November 17, 1998, final cleanup of the site was accomplished by processing 154 cubic yards of soil that included the reprocessing of the above-criteria pile. The above-criteria pile was approximately 16 cubic yards, consisting of 4.68 cubic yards diverted by SGS (including soil that was diverted due to periodic source checks) and soil that was diverted due to unscheduled pauses (approximately 11.68 cubic yards) in operations.

Overall volume reduction including reprocessing the hot pile was 99.56 percent, resulting in twenty-one 55-gallon drums of material requiring off-site disposal.

3.3 RADIOLOGICAL DATA

Depleted uranium was the only radionuclide processed in this project. The contamination was predicted to be very heterogeneous. SGS operations substantiated this prediction with data that indicated that the elevated activity could be removed by taking very little soil from the process and that the activities for the above and below-criteria soils exhibited dramatically different levels of activity, as shown in Table 3. While the sorting criteria for distributed contamination was set at 27 pCi/g, the below-criteria soil average was well below that level, at 14.77 pCi/g. The above-criteria soil average was 205.92 pCi/g. The above-criteria average activity excludes the large chunks of DU (see Figure 4 below) collected by hand from the ground, feed pile, or the oversize pile. Also, the above-criteria average activity excludes any activity seen by the SGS during periodic source checking of the system that verified both detector response and gate operation while soil was being processed.

Table 3

Date	Average Above-criteria Activity (pCi/g)	Average Below-criteria Activity (pCi/g)	Distributed Sorting Criteria (pCi/g)
11/6/98	367.7	14.9	27
11/7/98	180.0	12.7	27
11/9/98	242.3	13.7	27
11/10/98	218.5	13.0	27
11/11/98	134.0	15.0	27
11/12/98	194.6	12.7	27
11/13/98	115.0	24.4	27
11/14/98	198.4	12.1	27
11/15/98	228.9	15.9	27
11/16/98	210	16.9	27
11/16/98 Burn Site	169	12.2	27
11/17/98	223.5	14.7	27

Reprocessing of the above-criteria pile resulted primarily in the removal of most of the below-criteria soil that was generated due to the unscheduled pauses in operation as previously reported. The average activity of the below-criteria soil removed from the



above-criteria pile was 14.77 pCi/g, while the activity of the above-criteria soil after reprocessing remained relatively constant at 223 pCi/g.

No hazardous wastes were generated by SGS processing. Dry decontamination of the system resulted in no wastewater generation. Other wastes remaining were approximately two barrels of personal protective equipment (PPE). The soil remaining was packaged into twenty-one 55-gallon drums awaiting final disposition.



Figure 4

3.4 BURN SITE SUMMARY

In addition to the soil sorting activities for soil from ER Site 228A, a dump truck containing 5 cubic yards of soil from the Burn Site was brought to ER Site 228A for a pilot study. The contamination at the Burn Site was judged to be similar to that at ER Site 228A.

A total of 5.2 cubic yards of Burn Site soil was processed. A volume reduction of 99.4 percent was reported by the SGS. The average above-criteria activity reported by the SGS was 169 pCi/g, while the average below-criteria activity was reported as 12.2 pCi/g. The distributed contamination criteria for the Burn Site soil was set to 27 pCi/g and multiple particle factor of 4.

SECTION 4

4.0 SEGMENTED GATE SYSTEM COSTS

4.1 CONTRACTING METHOD

The SGS project was contracted by Sandia National Laboratories on a lump sum fixed price, with an optional production rate for a volume greater than 1800 cubic yards. Total invoiced cost for this project was \$220,000.

4.2 COST BREAKDOWN

Excavation costs included rental of two front-end loaders, shipment of field grizzly, and labor to excavate, pre-screen and stock pile approximately 1400 cubic yards of soil (1352 CY thru SGS, 10 CY oversize from pre-screening, and 70 CY oversize from SGS).

Mobilization costs included trucking and crane costs to deliver the SGS and delivery charges for heavy equipment, mobile office space, etc. Demobilization charges included pickup charges for the various equipment and facilities, crane services to load the SGS onto the trucks, and funding for preparation of the final report. Mobilization costs for transportation of the crew to the work site were invoiced at cost plus G&A and were not included in the defined mobilization costs.

Daily operational costs included crew wages, per diem, equipment rentals, PPE and daily operating supplies. Operational days included equipment unloading, assembly and calibration, site excavation, operation during soil processing, and disassembly, decontamination and loading of the equipment for shipment to the next job site. Truck transportation charges to the next site were considered part of the mobilization charges for the next client. In cases where the SGS is not scheduled for another project, trucking charges would be considered part of the demobilization.

Table 4

Cost element	Description	Subtotals
Task 1	Excavation	\$29,000
Task 2	Mobilization	\$41,300
Task 3	Processing	\$117,000
Task 4	Demobilization	\$32,340

Additional costs incurred by Sandia included ER Site 228A gully excavation, oversight



labor, health physics support, procurement of a water supply, fuel services, generator support, sample analysis, and waste disposal.

Processing costs for SGS operations provided by Thermo NUtech were approximately \$82 per cubic yard (\$117,000 divided by 1,432 cubic yards), including all soils. Overall costs for services provided by Thermo NUtech averaged about \$154 per yard. Processing costs reflect the relatively small volume processed. Increased volumes would leverage the mobilization and demobilization costs and should result in increased daily production volumes as a daily routine develops and soil is available for processing for full days.

SECTION 5

5.0 SCHEDULE

Figure 5 shows the tasks and schedule associated with the SGS project at SNL ER Site 228A. Since only one radionuclide was processed, only one calibration interval was required. The operations interval was not increased when the soil from the Burn Site was brought in since there was no requirement to isolate the soil from the surrounding site.

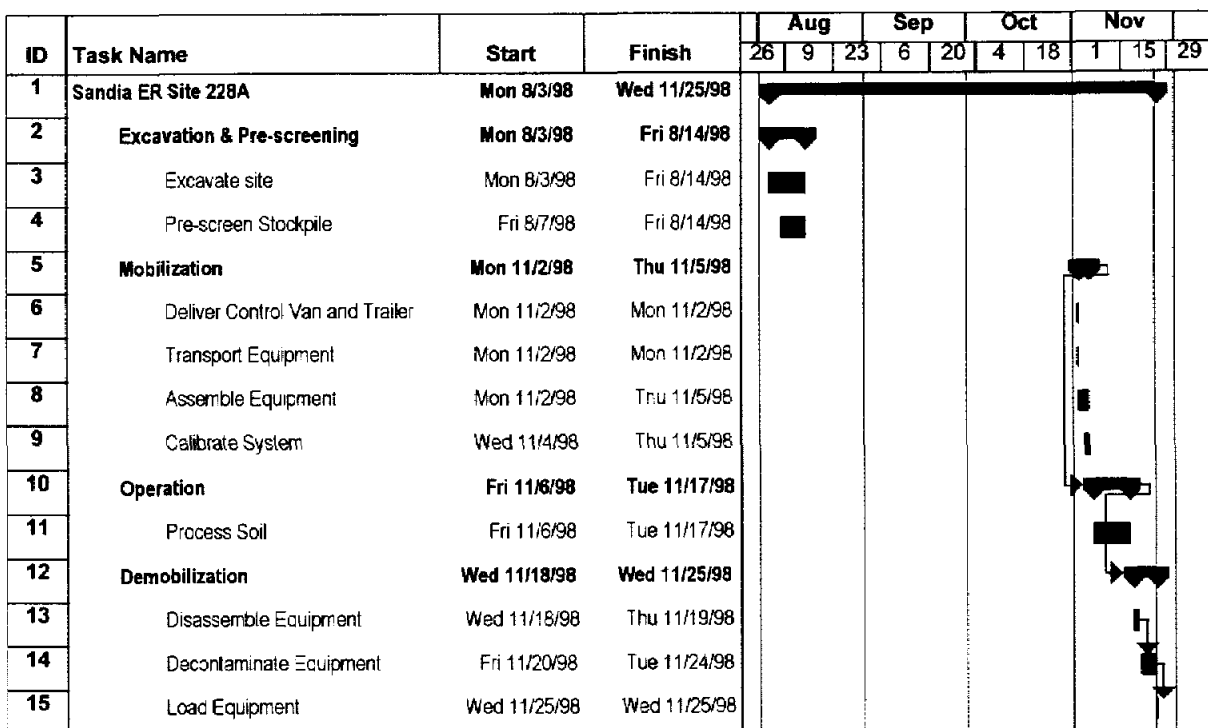


Figure 5. Project Schedule



SECTION 6

6.0 OBSERVATIONS AND LESSONS LEARNED

6.1 COST OBSERVATIONS AND LESSONS LEARNED

The unit cost for processing soil at Sandia ER Site 228A was approximately \$82 per cubic yard. The average daily processing time was 4.47 hours, significantly below the target of 7 hours per 10-hour day. There were two days when more than 7 hours of processing was achieved. The major impacts were from weather delays and equipment concerns. The impact of these factors would be significantly reduced on a larger project. The soil was very heterogeneous, containing only sporadic hot spots. This was the primary reason for the excellent volume reduction, which is the primary driver for overall cost reduction.

Operating time for larger projects may be impacted by any time required to reprocess the above-criteria pile to remove soil placed there by unscheduled operational pauses. Cost benefits could be achieved by analyzing the pause records and addressing the root causes.

6.2 PERFORMANCE OBSERVATIONS AND LESSONS LEARNED

Several factors impacted the performance and throughput of the SGS at ER Site 228A. The use of the field grizzly was a positive contributor to the ease of processing soil containing large oversize debris. By removing large debris before processing the soil, many of the challenges of keeping a uniform soil flow in the system were eliminated. While use of the field grizzly can sometimes lead to homogenization of the soil, the contaminant was very localized and appeared to be in actual fragments that were not dispersed as the soil was filtered through the grizzly.

The exception to uniform soil flow was the occurrence of screen/hammermill plant jams caused by rocks approximately 3 inches in diameter. These rocks would occasionally lodge between the feed chain and the feed chain drive gear, causing a lack of soil to the SGS, which in turn caused an unscheduled pause. This event had been observed during previous operations, but measures taken to limit the occurrence of this event were not successful, and will require more research.

The moisture content of the soil was near optimum, requiring less monitoring of soil flow through the gates.

6.3 SUMMARY

The application of the SGS to the remediation of Sandia National Laboratories ER Site 228A resulted in significantly reducing the volume of radionuclide contaminated soil that would require off-site disposal. The application of the SGS to the remediation of



radionuclide contaminated soils can be very effective in situations where the contaminant is heterogeneously distributed, the contaminant is well characterized and provides a suitable gamma signature for the SGS, and the soil type is amenable to processing on a conveyORIZED system in a layer one to two inches thick after removal of any significant debris. Figure 6 shows the clean pile in comparison to the drum of waste now requiring off-site disposal. Figure 7 shows the oversize rocks spread out in a 6-inch layer to be surveyed and released by Sandia personnel.

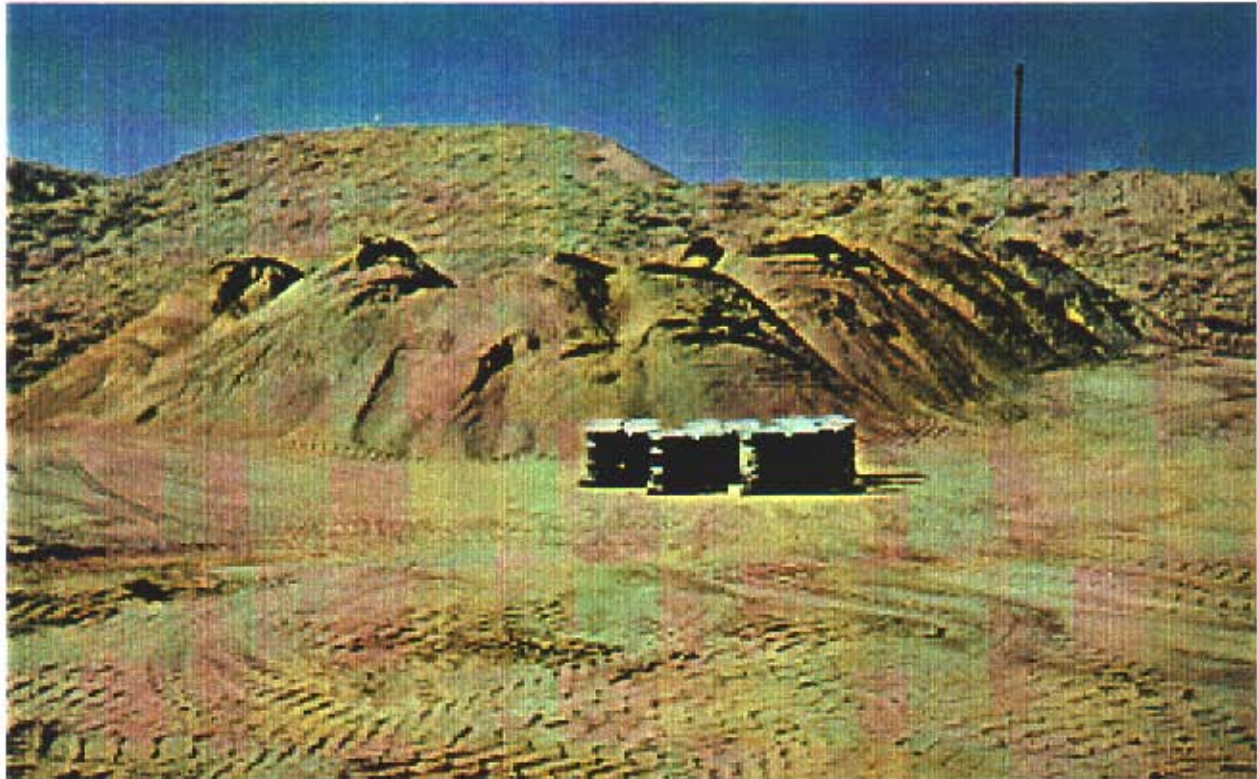


Figure 6



Figure 7

ANNEX 3-D
Field Implementation Plan
ER Site 228A, Centrifuge Dump Site
(July 1998)



Field Implementation Plan (FIP)
ER Site 228A - Centrifuge Dump Site
SNL/NM Environmental Restoration Project

Plan Authorization and Implementation

Prepared by John R. Copland
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Date 7/9/98

Reviewed by Sue Collins
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Date 7/9/98

Approved by Fran Nimick
Fran Nimick, 6133
Department Manager

Date 7/10/98

1. Project Information

Task Description: Collect soil samples and conduct remediation at Site 228A

Department No. 6133 Case No. 7225.2203 VCM Field Team Leader: John Copland

Work Plan Title: Voluntary Corrective Measures (VCM) Plan ER Project Site 228A - Centrifuge Dump Site, April 1998

Scheduled Start Date of VCM: July 13, 1998

Estimated Completion Date: December 1, 1998

2. Site Information

Operations/Technical Area: OU 1309, Tijeras Arroyo Site: 228A - Centrifuge Dump Site

Site 228A, the Centrifuge Dump Site, is located about 500 ft east of SNL/NM Technical Area II on the northern rim of Tijeras Arroyo (Figure 1). The site is approximately 1.3 acres in size. Site 228A is designated as a Radioactive Materials Management Area (RMMA) and a Contamination Area (CA). Environmental concern at Site 228A is primarily based upon depleted uranium (DU) fragments that were dumped along the arroyo rim along with other test debris from the nearby rocket-powered centrifuge, which was used from 1952 through 1956 for testing the reliability of nuclear-weapon components.

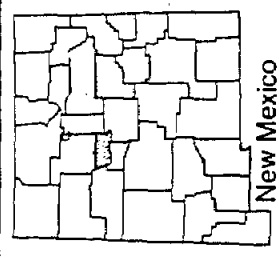
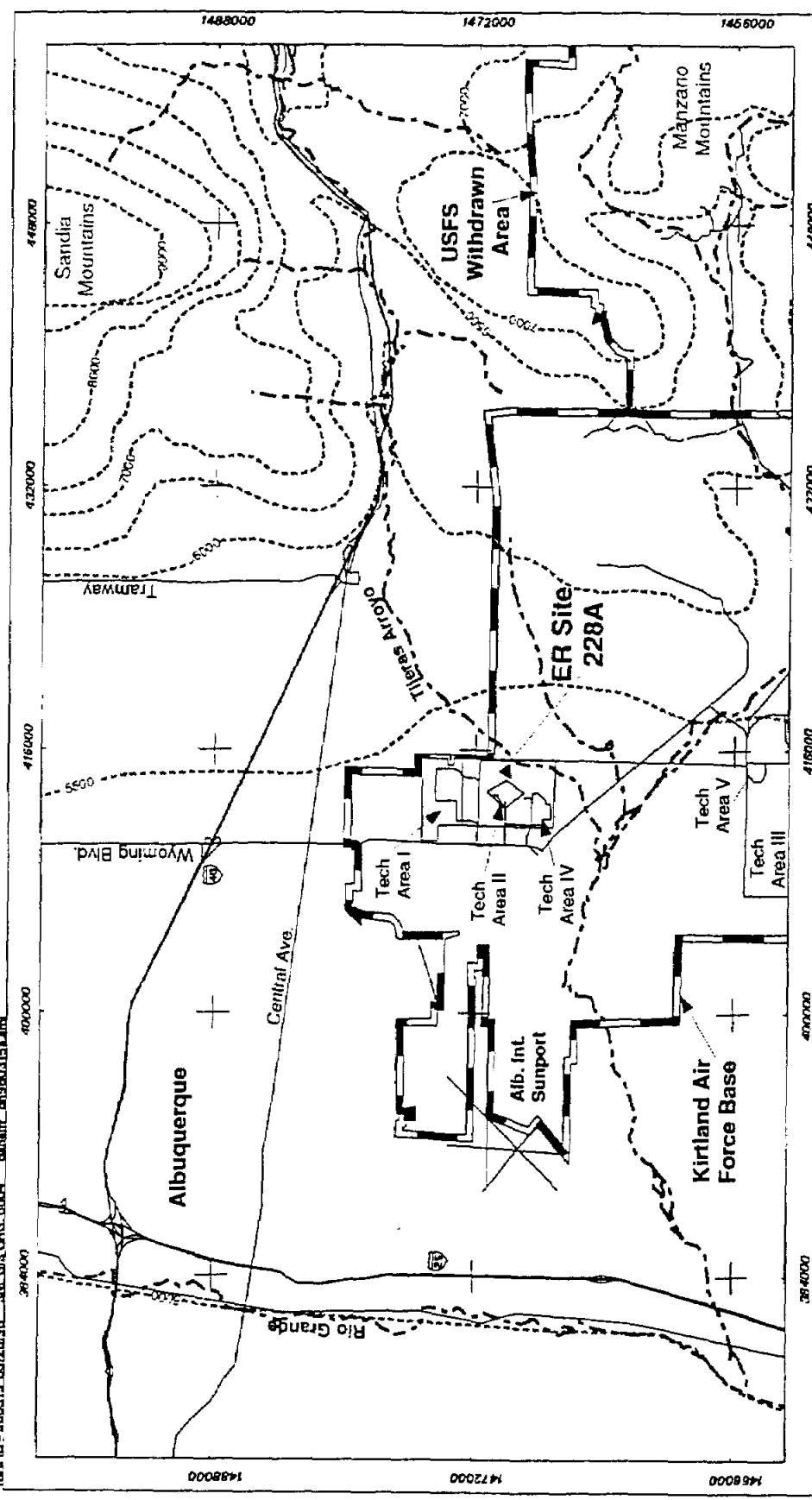
The majority of the test debris remained covered by soil and concrete slabs until heavy rainfall in July 1997 caused significant erosion in the gully. As a result, DU fragments were washed down onto a small alluvial fan on the edge of the arroyo (Figure 2). As a result, DU is present at two remediation areas (Scrappy-DU gully and Scooby-DU). DU is not present at the other two remediation areas (the construction-debris area and the buried-test-debris area). These four remediation areas will be excavated as part of the VCM. Another area, the clean-fill-ridge, also will be excavated.

3. Previous Investigations

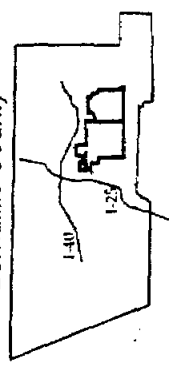
3.1 Soil Sampling

A total of 312 samples including 306 soil samples and 6 soil-vapor samples have been collected during eight phases of soil sampling at or near Site 228A (Table 1). The results are discussed below in chronological order.

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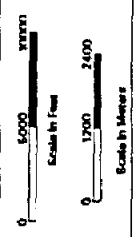
Bernalillo County



Legend

- ER Site 228A
- Major Road
- KAFB Boundary
- 500 Foot Contour
- Major Drainage
- SNL Technical Area

Figure 1.
SNL/NM ER Site 228A and
Kirtland Air Force Base



Sandia National Laboratories, New Mexico
Environmental Geographic Information System

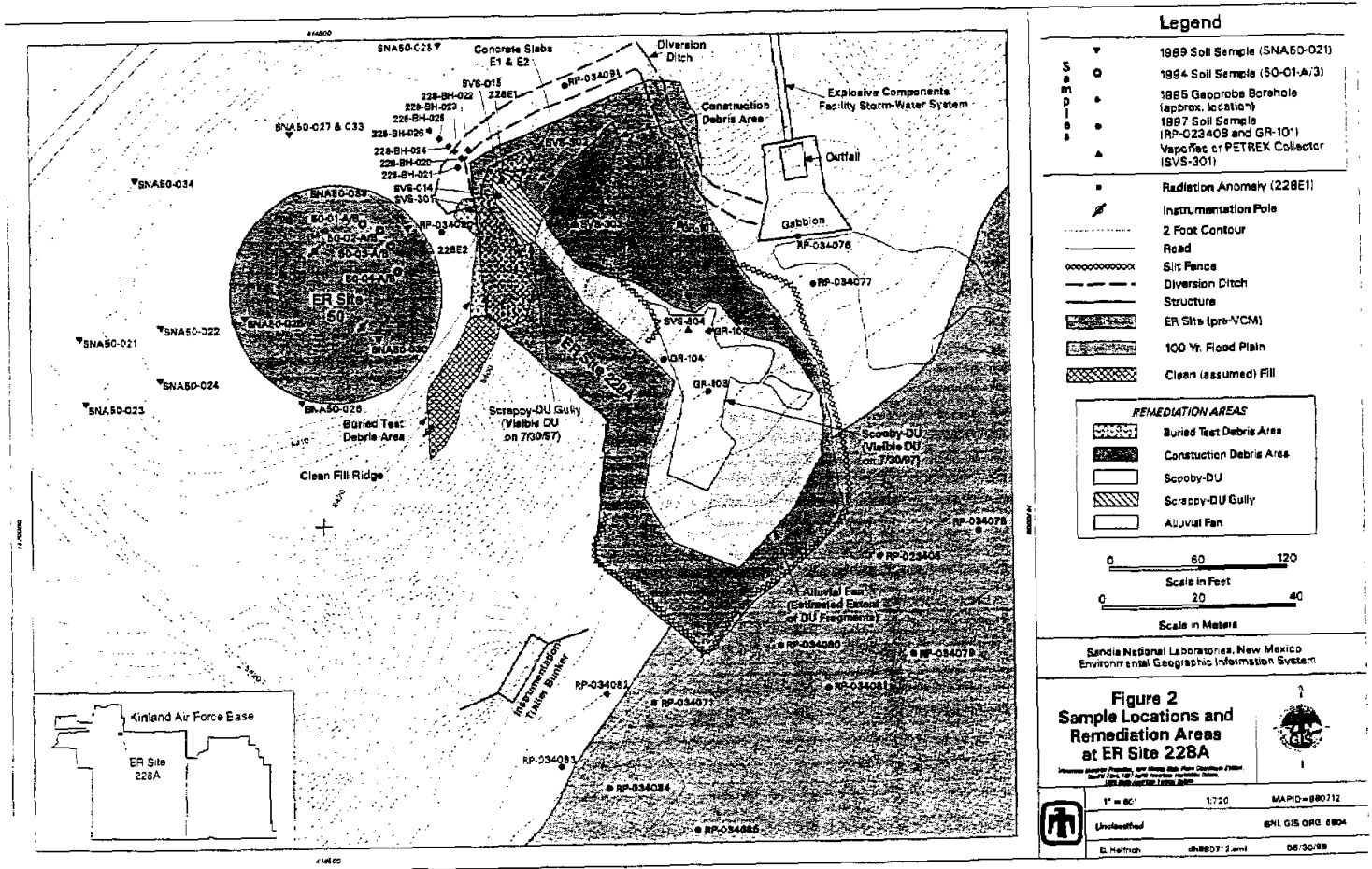


Table 1. Number of Soil and Soil-vapor Samples Collected at Sites 50 and 228A since 1989.

	Investigation										Total Samples
	Reconnaissance Data Report	Site 50 NFA Proposal	Initial Debris Removal	GeoProbe by Scrappy-DU gully	Tijeras Arroyo floodplain	Scooby-DU [RCTs]	Scooby-DU [TJAOU]	Geophysical Survey	Soil Piles from Segmented Gate System		
Analytical Suite											
DU / gamma-emitters ^a	--	8	3	28	14	12	4	14	2	85	
Isotopic U	10	8	--	--	--	--	--	--	--	18	
Isotopic Pu	--	8	--	--	--	--	--	--	--	8	
Total U	10	--	--	--	--	--	--	--	--	10	
Tritium	--	8	--	--	--	--	--	--	--	8	
TAL Metals	10	8	--	28	--	--	4	--	2	52	
TCLP Metals	10	--	3	--	--	--	--	--	2	15	
EP-TOX Metals	10	--	--	--	--	--	--	--	--	10	
HE Compounds	10	8	--	--	--	--	4	--	--	22	
VOCs	--	--	--	28	--	--	2 ^b	--	--	30	
SVOCs	10	--	--	--	--	--	4 ^b	--	--	14	
EP-TOX Pesticides	10	--	--	--	--	--	--	--	--	10	
TCLP Pesticides	10	--	--	--	--	--	--	--	--	10	
Herbicides	10	--	--	--	--	--	--	--	--	10	
PCBs	10	--	--	--	--	--	--	--	--	10	
Total Samples	110	48	6	84	14	12	18	14	6	312	
Sampling Date	9/89	9/94	9/94	8/95	8/97	8/97	12/97	1/98	3/98	--	

^aGamma Spectroscopy quantifies three decay series (U-235, U-238, and Th-232).

^bIncludes soil-vapor results from 5/95 and four VaporTec results from 9/97).

The first sampling occurred in 1989 when surface-soil samples were collected at 10 locations around the centrifuge (Site 50) as part of the SNL/NM Reconnaissance Data Report that supplemented the CEARP effort (Figure 2). These SNA50-series samples were analyzed by a Roy F. Weston Inc. laboratory for 11 suites of analytes: metals (target analyte list [TAL], extraction procedure toxicity [EP-TOX], and toxicity characteristic leachate procedure [TCLP]), pesticides (EP-TOX and TCLP), polychlorinated biphenyls (PCBs), herbicides (EP-TOX and TCLP), semi-volatile organic compounds (SVOCs), 2,4,6-trinitrotoluene (2,4,6-TNT), and isotopic/total uranium. The analytical results did not indicate any soil contamination in the vicinity of the centrifuge. Both TAL metals and uranium are within the range of recently established New Mexico Environment Department (NMED) Hazardous and Radioactive Materials Bureau (HRMB) background values for the Sandia North Supergroup soil. The other metal results were non-detect and/or were below the Resource Conservation and Recovery Act (RCRA) TCLP and EP-TOX standards. No pesticides, PCBs, herbicides, SVOCs, or 2,4,6-TNT were detected.

Soil samples were collected at the open side of the centrifuge berm in 1994. The soil-sampling results were used for the June 1995 No Further Action (NFA) proposal for Site 50. The eight soil samples (50-01-A, 50-01-B, 50-02-A, 50-02-B, 50-03-A, 50-03-B, 50-04-A, and 50-04-B) were analyzed for HE compounds, TAL metals, and radionuclides. The ENCOTEC Inc. laboratory analyzed the samples for HE compounds and TAL metals using EPA Methods 8330 and 6010/7471, respectively. The isotopic U, Pu, and tritium analyses were conducted by Quanterra Inc. using methods HASL-300 and EERF-H01. Gamma spectroscopy was conducted by the Department 7578 Personnel Monitoring and Laboratory Services. No HE compounds were detected in any of the soil samples. As shown in Table 2, three metals (arsenic, barium, and cadmium) of the eight RCRA metals slightly exceeded the HRMB background value. The uranium activities did not exceed the HRMB background values. Pu-238 and Pu-239/240 were not detected in any of the samples above the MDAs of 0.008 and 0.004 pCi/g, respectively. The greatest tritium activity was 0.038 pCi/g.

Table 2. Comparison of Total Metal Concentrations for Site 50 Soil Samples to Background Values.

RCRA Metals	Maximum concentration in Site 50 soil (mg/kg, ppm)	HRMB maximum background value for Sandia North Supergroup surface soil (mg/kg, ppm)
Arsenic (As)	8	5.6
Barium (Ba)	220	200
Cadmium (Cd)	1.6	<1
Chromium (Cr)-total	5	17.3
Lead (Pb)	25	39
Mercury (Hg)	<0.04	<0.25
Selenium (Se)	<0.025	<1
Silver (Ag)	<0.50	<1

Sample numbers: 50-01-A, 50-01-B, 50-02-A, 50-02-B, 50-03-A, 50-03-B, 50-04-A, 50-04-B.

Sampling date: September, 1994.

Analytical laboratory: ENCOTEC Inc.

Metal-debris and composite-soil samples were collected by Rust Geotech in September 1994. The analytical results for these samples are discussed in Section 3.2 (Debris Removal). Soil-vapor sampling results are also discussed elsewhere (Section 3.3 Soil-vapor Sampling). Additional results from soil samples collected during the comprehensive radiological survey and operation of the Segmented Gate System (SGS) are discussed in Section 3.4 (Comprehensive Radiological Survey) and Section 3.5 (Automated Radiological Segregation), respectively.

During July and August 1995, seven GeoProbe boreholes were sampled for gamma emitters, volatile organic compounds (VOCs), and RCRA metals. The boreholes were located at the north end of the Scrappy-DU gully (Figure 2). The soil samples were collected at depths of 4, 9, 14, and 19 ft BGL. Gamma spectroscopy was conducted by Department 7578 Personnel Monitoring and Laboratory Services. U-238 was not detected above the MDAs that ranged from 1.34 to 6.69 pCi/g. The samples also were analyzed by the Environmental Restoration Chemistry Laboratory (ERCL) for VOCs and TAL metals using EPA Methods 8240/8260 and 6010-modified. No VOCs were detected. A single "J" value was reported; the 4-ft sample from borehole 228-BH-020 tentatively contained 14 µg/kg (ppb) of acetone. The metal analyses were conducted using rather high scoping-sampling

detection limits at ERCL. The eight RCRA metals were either non-detect or were below the HRMB background values.

In August 1997, the ER Project and the SNL/NM Environmental Monitoring Department collected 14 surface-soil samples around ER Site 228A. Most of these RP-series samples were collected on the floodplain below the site. The samples were analyzed for gamma emitters by Department 7578 Personnel Monitoring and Laboratory Services with minimum detectable activities (MDAs) for DU that ranged from 1.72 to 4.29 picocuries per gram (pCi/g). No radioactive contamination was identified in the soil samples.

Also during August 1997, SNL/NM radiological control technicians (RCTs) picked up all the visible DU fragments at Scooby-DU and collected twelve soil samples (M-1 through M-12). Half of the soil samples were collected on Scooby-DU, while the other half were collected from a 10-ft wide zone that surrounded Scooby-DU. Gamma spectroscopy was conducted by Department 7578 Personnel Monitoring and Laboratory Services. The U-238 activities for the six Scooby-DU soil samples (M-1, M-2, M-3, M-4, M-5, and M-11) ranged from 8 to 6,000 pCi/g. The six surrounding-zone samples (M-6, M-7, M-8, M-9, M-10, and M-12) had U-238 activities in soil that ranged from <1.54 to 24.7 pCi/g.

In December 1997, four surface-soil samples (GR-101 through GR-104) were collected from randomly selected locations at Scooby-DU (Figure 2). However, these soil samples were not collected at 'hot spots.' The samples were analyzed for gamma-emitters, HE compounds, and TAL metals. Gamma spectroscopy was conducted by Department 7578 Personnel Monitoring and Laboratory Services. The range of U-238 activities in soil was <2.87 to 25.5 pCi/g, which exceeds the HRMB background value of 1.3 pCi/g. The samples also were analyzed by Environmental Restoration Chemistry Laboratory (ERCL) for 14 HE compounds and the 23 TAL metals (including the 8 RCRA metals) using EPA Methods 8330-modified and 6020, respectively. No HE compounds were detected in excess of the detection limits that ranged from 0.097 to 0.31 mg/kg (ppm). Except for cadmium and selenium, none of the RCRA metals exceeded the HRMB background values (Table 3). The cadmium concentrations ranged from 0.16 to 9.8 mg/kg (ppm), but just one of the four cadmium concentrations exceeded the HRMB background value of <1 mg/kg (ppm). Only one of the four selenium concentrations exceeded HRMB background value of 1 mg/kg (ppm); the selenium concentrations ranged from 0.64 J to 1.1 J mg/kg (ppm). All of the selenium values had a "J" qualifier (the values were greater than the method detection limit (MDL) but were less than the practical quantation limit [PQL]).

Table 3. Comparison of Metal Concentrations for Site 228A Soil Samples to Background Values.

RCRA Metal	Maximum total-metal concentration in Site 228A soil [mg/kg, ppm]	HRMB maximum background value for Sandia North Supergroup surface soil [mg/kg, ppm]
Arsenic (As)	1.8 J ^a	5.6
Barium (Ba)	91	200
Cadmium (Cd)	9.8	<1
Chromium (Cr)-total	7.9	17.3
Lead (Pb)	11	39
Mercury (Hg)	<0.04	<0.25
Selenium (Se)	1.1 J	<1
Silver (Ag)	0.86	<1

^aJ = result is greater than or equal to the MDL but is less than the PQL.

Sample numbers: TJAOU-228A-GR-101-0.1-S through TJAOU-228A-GR-104-0.1-S.

Sampling date: December, 1997.

Analytical laboratory: ERCL.

3.2 Debris Removal

In 1994, Rust Geotech identified and partially remediated radioactive anomalies 228E1 and 228E2, and collected four samples. Unfortunately, these two anomalies were partially covered by 1-ft thick concrete slabs, which limited the Rust Geotech effort. Some of the soil beneath the slabs was excavated and 12 drums of DU-contaminated soil

were generated. The largest DU fragment weighed about 40 pounds and was placed in a separate drum along with other DU fragments and metal debris. One of the pieces of metal debris was analyzed by gamma spectroscopy and had an U-238 activity of 24,300 pCi/g. The metal-debris sample did not pass the TCLP test because the sample yielded a cadmium concentration of 1.62 mg/l (ppm), which is slightly above the cadmium criterion of 1 mg/l (ppm) for hazardous waste determination (Table 4). This sample did not fail the TCLP test for six other RCRA metals (arsenic, barium, chromium, lead, selenium, and silver). Mercury was not considered to be a contaminant of concern (COC) and was therefore not an analyte. The results of the TCLP analyses and radiological screening required that the drum of DU-fragments be categorized as mixed waste.

Table 4. Concentrations of TCLP Metals in Metal-Debris and Composite-Soil Samples.

Metal	Concentration for metal-debris sample 228-031995-1-FR [mg/l, ppm]	Concentration for soil sample 228-042895-1-SS [mg/l, ppm]	Concentration for soil sample 228-042995-3-SS soil [mg/l, ppm]	Concentration for soil sample 228-042895-4-SS soil [mg/l, ppm]	RCRA Regulatory Level [mg/l, ppm]
Arsenic (As)	<0.127	<0.127	<0.127	<0.127	5
Barium (Ba)	<0.0033	0.889	0.880	0.784	100
Cadmium (Cd)	1.620	1.100	1.470	0.742	1
Chromium (Cr)	2.670	<0.0033	0.010	0.0089	5
Lead (Pb)	2.340	0.934	0.569	0.876	5
Selenium (Se)	1.680	<0.147	<0.147	0.172	1
Silver (Ag)	1.920	<0.0044	<0.0044	<0.0044	5

Sample numbers: 228-042895-1-SS, 228-042995-3-SS, 228-042895-4-SS, 228-031995-1-FR.

Sampling date: September, 1994.

Analytical laboratory: Grand Junction Project Office.

Using a 'one in five' container strategy, three composite soil samples were collected from the twelve soil drums and analyzed for gamma emitters and for TCLP metals. The U-238 activities for the three soil samples ranged from 9.95 to 72.90 pCi/g with a weighted average of 32.25 pCi/g. Only one soil sample passed the TCLP test. The three soil samples yielded cadmium concentrations ranging from 0.742 to 1.47 mg/l (ppm). The average cadmium concentration in soil was 1.104 mg/l (ppm), which is slightly above the RCRA regulatory level of 1 mg/l (ppm). The soil samples with elevated cadmium were apparently associated with a cadmium plated electrical-control box. The soil did not fail the TCLP tests for six other RCRA metals (Table 4). Mercury was not considered to be a COC and was therefore not an analyte. The 12 drums of soil were categorized as mixed waste.

3.3 Soil-vapor Sampling

Two phases of passive soil-vapor sampling (SVS) have been conducted at Site 228A. The first phase used Petrex™ collectors and the second phase used VaporTec™ collectors. The first SVS phase was conducted in May 1995 using two Petrex™ collectors near radioactive anomalies 228E1 and 228E2. The Petrex™ collectors were analyzed by thermal desorption/mass spectrometry for only two VOCs (perchloroethylene [PCE] and trichloroethylene [TCE]). Petrex location SVS-014 yielded 2,229 total ion counts (tics) for PCE; TCE was not detected. Petrex™ location SVS-015 yielded 1,929,050 tics of PCE, and 309,448 tics of TCE. In September 1997, additional soil-vapor samples were collected at four locations (SVS-301 through SVS-304) using VaporTec™ collectors, which were subsequently analyzed by gas chromatography using EPA Methods 8021/8015-modified. The collectors were analyzed for benzene, toluene, ethylbenzene, xylenes, total petroleum hydrocarbons (TPH) - gasoline, TPH-diesel, and chlorinated solvents. The maximum values for benzene, toluene, and ethylbenzene were 1.12, 4.61, and 1.97 nanograms (trillionth of a gram), respectively. Xylenes were not detected. The reportings of TPH-gasoline and TPH-diesel values were not considered valid because these two analytes also were detected in the trip blank. Only one chlorinated solvent, 1,1,2-trichloroethane (1,1,2-TCA), was detected. However, the value of 4.4 nanograms for 1,1,2-TCA was not confirmed in the duplicate collector. The low levels of organic compounds measured in both soil-vapor surveys imply that corresponding soil samples are not expected to contain concentrations of either VOCs or SVOCs in excess of 1 mg/kg (ppm).

3.4 Comprehensive Radiological Survey

In conjunction with geophysical surveys, a comprehensive and quantitative radiological survey was conducted across most of Site 228A in January 1998. A DU-specific methodology was developed for the site. A Ludlum 44-10 sodium-iodide (NaI) scintillation detector coupled to a Ludlum 2350-1 ratemeter was used for measuring gamma radiation. A series of empirical tests was conducted using the typical, weathered DU fragments found onsite. The sensitivity of the NaI detector was evaluated both vertically and laterally, and an optimal scanning height and sweeping pattern was determined for the site. A grid spacing of 3 ft was used; therefore, each radioactive anomaly represented an integrated value for a 3 ft by 3 ft area. Because of the relatively low energy level of gamma radiation inherent to DU and the shielding capacity of the soil, the detector was determined to be sensitive to DU that was buried shallower than 0.5 ft. Survey data from an undisturbed, nearby plot was used to determine that background gamma radiation for the site was approximately 12,500 counts per minute (cpm). Gamma spectroscopy results for 14 soil samples collected from Scooby-DU and the background plot were used to determine a cpm to pCi/g conversion factor. The radiological survey identified numerous DU anomalies across Scooby-DU with approximately 60 of the DU anomalies being above the VCM Proposed Cleanup Value of 271 pCi/g. The cleanup goal is a risk-based Preliminary Remediation Goal (PRG) from the VCM Plan.

3.5 Automated Radiological Screening

During March 1998, approximately 2.6 cubic yards of DU-contaminated soil was screened for radionuclides with the automated Segmented Gate System (SGS), which was operated by Thermo NUTech™, Inc. The soil passed through a series of computerized detectors and was segregated into a 'hot' pile and a 'cold' pile according to DU content. A 38-percent volume reduction was achieved using a U-238 screening-level of 30.5 pCi/g. Total-metal analyses also were conducted on two soil samples. One sample each was collected from the hot pile and the cold pile. Neither soil sample exceeded the HRMB background values (Table 5).

Table 5. Comparison of Total Metal Concentrations in Hot-Pile and Cold-Pile Soil Samples to background.

Metal	Concentration in Site 228A Hot-Pile soil [mg/kg, ppm]	Concentration in Site 228A Cold-Pile soil [mg/kg, ppm]	HRMB Maximum Background for Sandia North Supergroup surface soil [mg/kg, ppm]
Arsenic (As)	2.5	1.3 J	5.6
Barium (Ba)	95	75	200
Cadmium (Cd)	0.47	0.47	<1
Chromium (Cr) -total	10	6.2	17.3
Lead (Pb)	11	7.4	39
Mercury (Hg)	<0.04	<0.04	<0.25
Selenium (Se)	0.4 J	0.32	<1
Silver (Ag)	0.12 J	0.069 J	<1

J = result is greater than or equal to the MDL but is less than the PQL.

Sample numbers: hot pile (037365-002), cold pile (037366-002).

Sampling date: March, 1998.

Analytical laboratory: ERCL.

The two soil samples from the SGS also were analyzed for gamma emitters and TCLP metals. The samples were analyzed for gamma emitters by Department 7578 Personnel Monitoring and Laboratory Services. The U-238 activities in soil were 174 and 12 pCi/g for the hot-pile and cold-pile samples, respectively. As shown in Table 6, the samples also were analyzed for TCLP metals by Core Laboratories using EPA Methods 6010A/7470. Only two metals (barium and cadmium) were detected by the TCLP method. However, the concentrations of barium and cadmium were well below the RCRA regulatory levels.

Table 6. Comparison of TCLP Metal Concentrations in Hot-Pile and Cold-Pile Soil Samples to RCRA Regulatory Levels.

Metal	Concentration in Hot Pile soil [mg/l, ppm]	Concentration in Cold Pile soil [mg/l, ppm]	RCRA Regulatory Level [mg/l, ppm]
Arsenic (As)	0.0489 Ja	<0.033079	5
Barium (Ba)	0.889	0.951	100
Cadmium (Cd)	0.0173	0.0254	1
Chromium (Cr)-total	<0.003826	<0.003826	5
Lead (Pb)	0.0392 J	<0.024842	5
Mercury (Hg)	<0.000047	<0.000047	0.2
Selenium (Se)	<0.054874	<0.054874	1
Silver (Ag)	0.00424 J	<0.002914	5

aJ = result is greater than or equal to the MDL but is less than the PQL.

Sample numbers: hot-pile (037365-003), cold-pile (037366-003)

Sampling date: March, 1998.

Analytical laboratory: Core Labs, Inc.

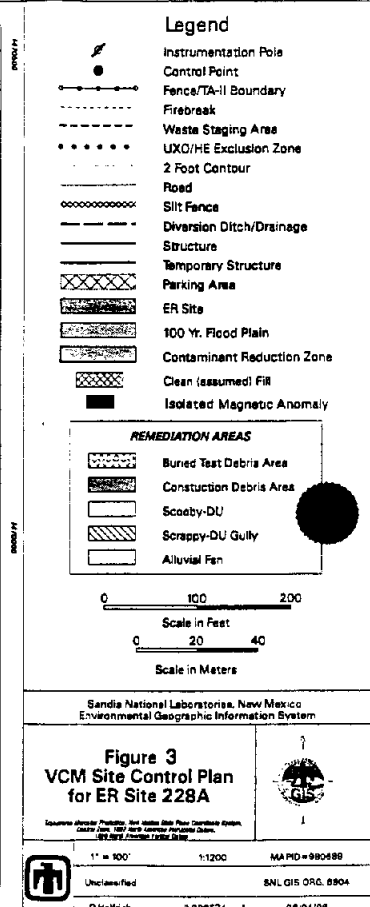
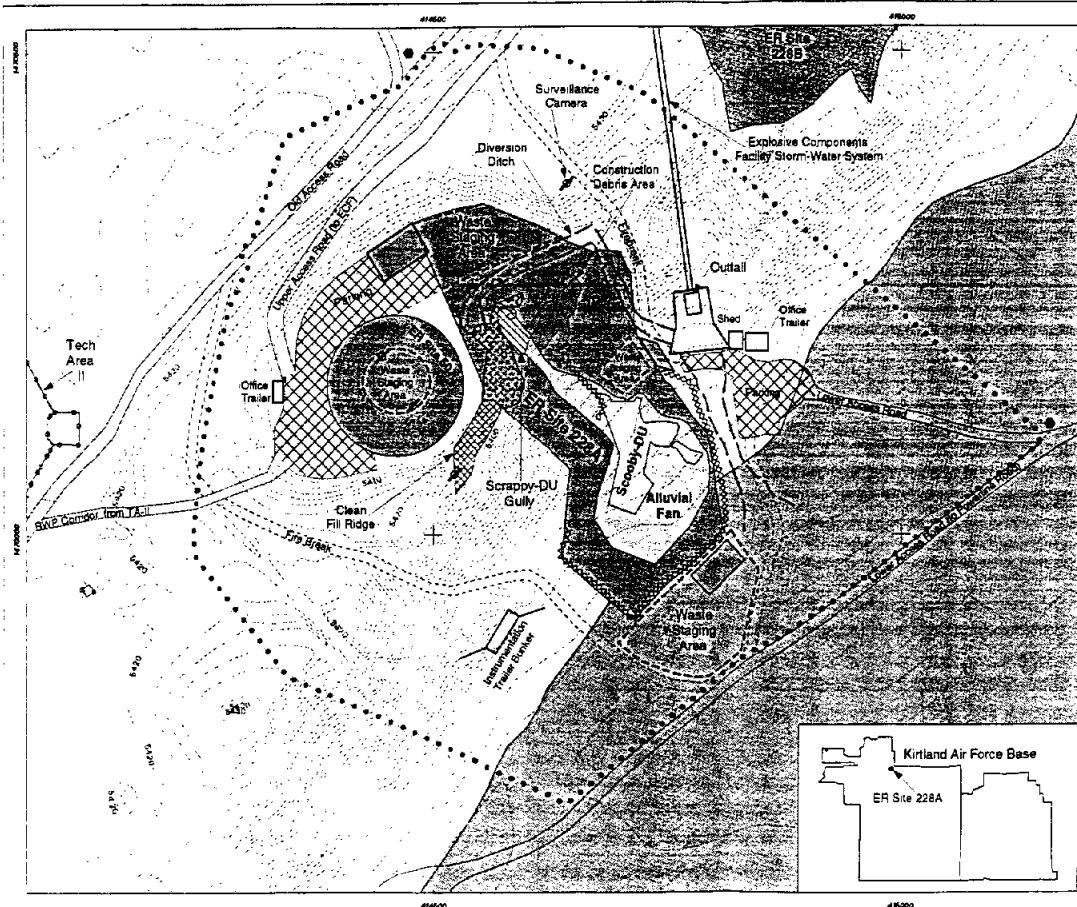
4.0 Contaminants of Concern and Types of Debris

The COCs for Site 228A are: DU, asbestos, cadmium, HE compounds, VOCs, and SVOCs. These COCs are based upon sampling results, memoranda, and visual observations. DU is the only radionuclide known to have been used at the centrifuge. The potential VOCs are PCE, TCE, bromochloromethane, methylene chloride (dichloromethane), and 1,1,1-trichloroethane (1,1,1-TCA). Bromochloromethane, methylene chloride, and 1,1,1-TCA are inferred from recent Material Safety Data Sheets (MSDSs) to have been the solvents present in 1950s-vintage Stresscoat™ lacquer, which had been painted on some test units prior to testing. The SVOCs are inferred from soil-vapor results. The results of soil-sampling and radiological surveys indicate that the locations of DU and other COCs are coincident.

The Site 228A debris includes: weathered DU fragments (schoepite); concrete slabs; black rubber pads; test-debris metal (aluminum and steel); concrete sphere pieces; nylon harness webbing; epoxy-encapsulated electrical junction boxes; electrical wire cables and connectors; concrete rubble with steel rebar/mesh; miscellaneous construction debris including wire mesh, glass pieces, and lumber; fragments of non-friable Transite™ asbestos sheets; steel mesh and rebar; a thermal-battery case; and an electrical control box. No oil-stained soil has been seen at the site. The potential also exists for buried unexploded ordnance/high explosive (UXO/HE) material to still be in or near the Scrappy-DU gully. Four types of UXO/HE hazards may be present: rocket motors, HE-warhead components, instrumentation-cable release charges, and thermal batteries (a RCRA-reactive hazard).

The physical, chemical, and radioactive hazards with respect to worker safety are well understood for Site 228A. As shown on Figure 3, the Site 228A VCM activities will be concentrated at five areas:

- clean-fill ridge;
- the construction-debris area;
- the buried-test-debris area;
- the Scrappy-DU gully; and
- Scooby-DU.



5.0 Scope of Work

The field work at Site 228A will consist of:

- excavating DU-contaminated soil, DU fragments, and test debris;
- loading grossly elevated DU-contaminated soil and test debris directly into 744 boxes;
- stockpiling soil piles that will be screened by the SGS;
- separating cobbles from soil prior to the SGS operation;
- operating the SGS for DU-waste-reduction purposes;
- loading DU-contaminated soil into 55-gallon drums;
- segregating non-radioactive construction and test debris;
- moving concrete slabs;
- possible scraping or brushing of concrete slabs to remove DU fragments;
- implementing waste-management procedures;
- collecting soil samples (grab, hand auger, or GeoProbe™);
- collecting debris samples;
- inspecting debris for UXO/HE material;
- excavating and benching clean soil;
- installing site-control measures;
- installing and maintaining surface-water controls;
- conducting radiological and geophysical surveys;
- decontaminating workers and equipment;
- final-verification sampling; and
- contouring and reseeded the site.

6. Objectives

This FIP contains the procedures, requirements, and specific instructions for performing field work at Site 228A and supplements the VCM Plan and Waste Management Plan (WMP). The specific objectives of this FIP are:

- **Sampling:** Collect samples for guiding the excavation of DU-contaminated soil, characterizing waste, and preparing final-verification soil samples.
- **Analytical:** To obtain sufficient analytical data for achieving the VCM Proposed Cleanup Values and to satisfy the waste acceptance criteria (WAC) for either Envirocare, Inc. or the Nevada Test Site (NTS). The VCM Proposed Cleanup Values are derived from the Preliminary Remediation Goals (PRGs), which are listed below in Table 7. The primary cleanup goal for the VCM is 271 pCi/g of DU in soil, which is based upon a human health risk assessment. The other cleanup goal relevant to DU is based upon the ecological-risk based goal of 100 ppm total uranium in soil; this value is approximately equivalent to 33 pCi/g of DU in soil. However, the assumptions inherent in the ecological risk assessment are so unreasonable that the 100 ppm value is probably not appropriate to Site 228A.

Table 7. Compilation of Risk-Based PRGs and the VCM Proposed Cleanup Values.
(Units of mg/kg [ppm] for inorganics and organics; units of pCi/g for radionuclides.)

Potential COC	Human Health Risk-Based PRG ¹	Ecological Risk-Based PRG	VCM Proposed Cleanup Value
<i>Inorganics (metals)</i>			
Arsenic	1.9	20	5.6 ²
Barium	66,502	510	510
Cadmium	510	210	210
Chromium III	3,837	42,000	3,837
Chromium VI	450	1,900	450
Chromium-total	n.a. ³	n.a.	450
Lead	2,000	12,000	2,000
Mercury	306	260	260
Selenium	5,110	5.9	5.9
Silver	5,110	1,600	1,600
Uranium-total	3,066	100	100
<i>Organics</i>			
Benzene	1.4	230	1.4
Bromochloromethane	n.a.	200	200
Ethylbenzene	8,779	800	800
Methylene Chloride (Dichloromethane)	15	61	15
Tetrachloroethene (Perchloroethylene)	15	6.3	6.3
1,1,1-Trichloroethane (Methyl Chloroform)	3,117	9,300	3,117
1,1,2-Trichloroethane	17	26	17
TCE (Trichloroethene)	8.7	6.3	6.3
Toluene	2,697	230	230
RDX (Cyclonite)	260	19	19
Acenaphthene	35,630	29	29
Anthracene	255,337	800	800
Benzo(a)pyrene	0.39	6.6	0.39
Fluoranthene	38,904	18	18
Naphthalene	10,661	7.4	7.4
Phenanthrene	35,630	7.9	7.9
Pyrene	29,474	9.1	9.1
<i>Radionuclides</i>			
U-234	330	n.a.	330
U-235	121	n.a.	121
U-238	271	n.a.	271

¹The human health risk-based PRG is the lower of the noncarcinogenic (HQ=1) PRG or the excess-cancer-risk PRG (10⁻⁵ for Class C carcinogens, 10⁻⁶ for Class A and B carcinogens, 10⁻⁶ for unclassified carcinogens).

²The cleanup level for arsenic is the HRMB background value.

³n.a. = not applicable.

7. Data Use

Regulatory Program

RCRA

SNL/NM ER Project: Site 228A VCM Plan

8. Organization

Management:	Department Manager	<u>Fran Nimick</u>	Organization	<u>6133</u>
	OU 1309 Task Leader	<u>Sue Collins</u>	Organization	<u>6133</u>
	Assistant Task Leader	<u>John Copland</u>	Organization	<u>6133</u>
Sampling:	Field Team Leader	<u>John Copland</u>	Organization	<u>6133</u>
	ERFO Coordinator	<u>Nelson Capitan</u>	Organization	<u>6131</u>
Analytical:	Sample Management	<u>Doug Salmi</u>	Organization	<u>7578</u>
	Analytical Laboratory	<u>CORE Denver</u>	Lab Contact	<u>Tim Kellogg</u>
	Analytical Laboratory	<u>SNL/NM RP</u>	Lab Contact	<u>Amir Mohagheghi</u>

9. Health and Safety

Health and Safety Plan: HASP for Site 228A – Centrifuge Dump Site

Date: April 1998

Notifications and Communications

One adjacent facility requires notification before field works begins at Site 228A. The Classified Waste Landfill (Site 2) project at TA-II shall be notified by calling Paula Slavin (284-2496) or Bob Galloway (844-0922).

10. Sample Collection

Sample Media: X Environmental X Waste

Matrix Type: Soil, metal, concrete, other debris

Sampling Approach and Method

Three types of samples (excavation-work, waste-characterization, and final-verification) will be collected. Because DU is the primary COC at Site 228A and can be readily detected by field instruments, the required number of soil samples will be minimized. The planned sampling frequency is also based on the fact that previous soil-sampling results indicate that any other possible contaminants, such as cadmium, will be co-located with DU.

Excavation Work

Soil samples will be collected during the excavation work for guiding the remediation activity. Many of these samples will be analyzed on a overnight-rush basis by the onsite SNL/NM Personnel Monitoring and Laboratory Services laboratory (Amir's lab). Approximately 30 grab samples will be collected.

Waste Characterization

Samples will be collected for waste-characterization purposes. These samples (soil and debris) are discussed in the Site 228A Waste Management Plan. The Site 228A team will work with the ER Waste Management Coordinator to ensure that adequate samples are collected. The WAC for both Envirocare, Inc. and NTS will be considered.

Final Verification

After the excavation work has been completed and analytical results have been reviewed for both the excavation-work and waste-characterization samples, a final round of verification samples will be collected to demonstrate that the VCM Proposed Cleanup Values have been achieved. Table 8 lists the number of soil samples that will be collected at various areas across the site. Soil samples for radionuclide analyses will be collected at each final-

verification location, while samples for other analyses will be collected at either 50 or 20 percent of the final-verification locations (Table 8). Only unique, not composite, samples will be collected.

Final-verification samples will be collected according to the following criteria.

- No visible DU or debris remains in the excavation(s).
- A sampling-grid spacing of 25 ft will be used at the alluvial fan and Scooby-DU.
- A sampling-grid spacing of 10 ft will be used at the Scrappy-DU gully.
- Verification radiological surveys indicate that no anomalies exceed the VCM Proposed Cleanup values.
- Verification geophysical surveys indicate that no metallic debris remain buried in the excavation(s).
- No VOC or SVOC contamination greater than 5 ppm by volume is detected by a PID or FID.
- Geologic evidence is found to distinguish natural deposits from fill material, if possible.

Table 8. Estimated Number of Final-verification Soil Samples for the Site 228A VCM.

Area	Sample Locations	Radionuclides (100%)	RCRA Metals (50%)	HE (20%)	VOCs (20%)	SVOCs (20%)
Scooby-DU and the Scrappy-DU gully	55	55	28	11	11	11
Construction Debris	7	7	4	2	2	2
Buried Test Debris	10	10	5	2	2	2
Floodplain below Scooby-DU	10	10	5	2	2	2
Clean-Fill Ridge (non-debris area)	5	5	3	1	1	1
Vicinity of Centrifuge	10	10	5	2	2	2
Total	97	97	50	20	20	20

Sampling Procedures

The sampling procedures are listed in Table 9; however, this site-specific FIP should be used as the primary guidance for the field work. Soil samples will be collected using grab, hand-auger, and GeoProbe™ techniques. All samples will be immediately labeled and placed in a cooler. Samples for radiological analyses will be stored at ambient temperatures; samples for non-radiological analyses will be stored at 4°C. A chain-of-custody will be completed using the sample nomenclature in Section 14. A Radiological Control Technician (RCT) will frisk and swipe the sample containers before allowing them to be removed from the site. The cooler(s) and samples will be stored at the ERFO RMMA until released by RP. Samples for off-site analyses will be delivered to the Sample Management Office (SMO) for processing and shipment to the appropriate analytical laboratory. Samples for on-site analyses will be hand delivered by ER or RP staff. A completed Analysis Request and Chain-of-Custody form (ARCO) will accompany each shipment.

Decontamination

Decontamination will entail cleaning a wide variety of equipment ranging from hand trowels to heavy equipment. Dry-decontamination techniques, such as scraping with a wire brush and wiping with paper towels, will be the preferred method. The sampling equipment will be decontaminated after each sample is collected (FOP 94-26). Before removal from the site, all cleaned equipment will be frisked and released by an RCT. In accordance with Jim Fish's memorandum of June 25, 1996, decontamination water may be discharged directly to the ground surface without being sampled, provided that there is reason to believe that the sampling equipment has not brought up any new contamination that does not already exist on the ground surface. Discharges of decontamination water to the ground surface will be less than 50 gallons per week and less than 5 gallons per hour. Water will not be discharged in areas prone to erosion. Also, because soil sampling will occur in many areas of the site, water will not be discharged in an area that will be sampled later. Decontamination water also may be placed in open-top drums or left on a temporary decontamination pad for evaporation; an RCT will survey any resulting residue.

Table 9. Applicable Operating Procedures for Sampling Activities.

Procedure #	Procedure Title
FOP 92-04	Field Operating Procedure for Field Logbook Content and Control
FOP 94-01	Safety Meetings, Inspections, and Pre-Entry Briefings
FOP 94-25	Documentation of Field Activities
FOP 94-26	General Equipment Decontamination
FOP 94-28	Health and Safety Monitoring of Organic Vapors (FID and PID)
FOP 94-34	Field Sample Management and Custody
FOP 94-54	Surface Sediment/Soil Sampling
FOP 94-57	Decontaminating Drilling and Other Field Equipment
FOP 94-68	Field Change Control
FOP 94-69	Personnel Decontamination (Level D, C, and B Protection)
FOP 94-78	Environmental Restoration Project Waste Management and Characterization Procedure
TOP 94-03	Verification and Validation of Chemical and Radiochemical Data
AOP 94-22	Sample Management Office User's Guide
AOP 94-24	System and Performance Audits
AOP 94-25	Deficiency Reporting
AOP 95-16	Administrative Operating Procedure for Sample Management and Custody
RPOP 04-0411	Contamination Survey of Materials, Equipment and Portable Facilities to be Released for Unrestricted Use
RPOP 04-412	Contamination Survey of Vehicles and Heavy Equipment to be Released for Unrestricted Use

Waste Disposal

The soil at Site 228A will be managed using the Site 228A WMP which includes the SNL/NM Soil Pile Management Plan. Most of the other waste will initially be labeled as 'mixed waste' because of the DU and possible metals content; it is anticipated that most waste will subsequently be labeled as 'low level radioactive waste' after TCLP metal results are received. A less-than-90-day waste accumulation area (WAA) will be established in the Site 228A waste-staging area. Waste containers shall be clearly labeled with the date and sample reference numbers. A copy of the waste log with the sample reference numbers and ARCO numbers will be delivered to the ER Waste Management Coordinator. The ARCO shall clearly identify the sample as 'waste characterization' so that the analytical laboratories can perform the analysis in a timely manner to ensure the 90-day waste accumulation period is not exceeded. Personal Protective Equipment (PPE) will be handled in accordance with the Site 228A HASP and Radiological Work Permits (RWPs).

11. Analytical Requirements

The detection limit for each COC (chemical or radionuclide) will be lower than the respective VCM Proposed Cleanup Value and the HRMB Maximum Background value. These values are specified in the Site 228A VCM Plan. The detection limits will be verified by contacting each of the appropriate laboratories. Samples for off-site analyses will be shipped via the SMO. Samples for on-site analyses will be hand delivered by ER staff. A bottle order for sample containers will be made through the SMO contact at least two weeks prior to sampling; a copy of this FIP will be provided to the SMO. Table 10 lists the analytical methods for soil and debris. As needed, the soil samples will be analyzed for gamma-emitting radionuclides, gross alpha/beta, isotopic uranium, total uranium, RCRA metals, TCLP metals/VOCs/SVOCs, HE compounds, VOCs, and SVOCs.

Table 10. Analytical Methods for Soil and Debris Samples.

Analyte	Purpose	Analytical Method
Gamma-emitting radionuclides	Cleanup Verification and Waste Characterization	EPA 901.1 (gamma spectroscopy)
Gross alpha/beta	Cleanup Verification	EPA 900.0 (or SW 846 9310)
Isotopic uranium	Cleanup Verification and Waste Characterization	Lab specific
Total uranium	Cleanup Verification	Lab specific
Tritium	Waste Characterization	Lab specific
RCRA metals	Cleanup Verification	EPA 6010/7000 Series
TCLP metals + Cu, Zn, Hg	Waste Characterization	EPA 1311
TCLP VOCs	Waste Characterization	EPA 1311
TCLP SVOCs	Waste Characterization	EPA 1311
HE compounds	Cleanup Verification and Waste Characterization	EPA 8330
VOCs	Cleanup Verification and Waste Characterization	EPA 8260
SVOCs	Cleanup Verification and Waste Characterization	EPA 8270
Specific WAC for Envirocare, Inc.	Waste Characterization	Lab specific
Specific WAC for NTS	Waste Characterization	Lab specific

Listed in Table 11 are the calibration requirements for the field-screening instruments. VOCs and SVOCs will be monitored with the use of either a Photoionization Detector (PID) or a Flame Ionization Detector (FID). Radiological surveys will be conducted using radiation meters supplied by RP. Geophysical instruments such as a metal detector will be used.

Table 11. Calibration Requirements for Field Instruments.

Instrument	Calibration	Frequency	Acceptance Criteria	Corrective Action
PID or FID	<ul style="list-style-type: none"> Calibration for accuracy Duplicate sample for precision 	Daily	<ul style="list-style-type: none"> + 10% of gas standard < 20% Relative Percent Difference (RPD) 	<ul style="list-style-type: none"> Recalibrate: repair/replace instrument
Radiation Meter	<ul style="list-style-type: none"> Calibration for accuracy 	Daily	<ul style="list-style-type: none"> RP procedures 	<ul style="list-style-type: none"> Replace meter
Geophysical Instruments	<ul style="list-style-type: none"> Calibration for accuracy 	Daily	<ul style="list-style-type: none"> Instrument manual 	<ul style="list-style-type: none"> Recalibrate: repair/replace instrument

12. Quality Control

Additional samples for quality assurance/quality control (QA/QC) purposes will be collected during the final-verification sampling. These samples will be collected according to the ER Project Quality Assurance Plan (QAP). The ratios for collecting/preparing the QA/QC samples are specified in Table 12. Debris and other waste-characterization sampling will not need to adhere to Table 12.

Table 12. Collection/preparation Ratios for QA/QC Samples collected during final-verification sampling.

Field		Laboratory	
X Duplicate samples	5% of soil samples	Replicate	5% or n.a.
X Equipment Blank	1 per day	X LCS	5% or 1 per batch
X Trip Blank for VOCs	1 per shipment	X MS	5% or 1 per batch
Other		X MSD	5% or 1 per batch
		X Method blank	1 per analytical batch
		X Surrogate spike	all GC/MS samples

Equipment wash (rinsate) samples are the only type of water samples that will be collected during the VCM. Table 13 lists the analytical methods for the rinsate samples.

Table 13. Analytical Methods for Equipment Wash (Rinsate) Samples.

Analyte	Analytical Method
Gamma-emitting radionuclides	Lab Specific
RCRA metals	EPA 6010/7000 Series (200 series or 200.7)
HE compounds	EPA 8330 /
VOCs	EPA 8240 / 624
SVOCs	EPA 8270 / 625

13. Data Validation

Analytical reports will be reviewed using the data-validation procedure TOP 94-03.

14. Sample Nomenclature

The "ER Sample ID" nomenclature in Table 13 will be used to identify the samples collected at Site 228A. For example, a typical 'ER Sample ID' will be TJAOU-228A-GR-120-1.5-S for a grab sample of soil collected at a depth of 1-1.5 ft at location 120. The location number of 120 will be the starting point for the VCM soil samples. A block of 'random SMO numbers' will be obtained from the automated phone number 284-5514.

Table 13. ER Sample ID nomenclature.

Operable Unit ¹		Site		Location Category		Location Number		Sample depth ² (ft)	-	Sampling Media
AAAAA				NNN		AAA		NNNN.N	-	AAA
3 to 5 digits				2 to 3 digits		3 digits		5 digits	-	1 to 3 digits
<i>Example:</i>										
Tijeras Arroyo		228A		Grab		120		5.5		soil
<i>Nomenclature:</i>										
TJAOU	-	228A	-	GR	-	120	-	5.5	-	S

Choices for Location Category	Choices for Sampling Media Category
ARY = Arroyo	AIR = Air
AS = Air Sampler	GW = Ground Water
BH = Borehole (Drilled or hand augured)	GWD = Ground Water Duplicate
BT = Biota	GWS = Ground Water Split
CH = Channel	PW = Purge Water
DP = Drive Point	S = Soil and rock (includes cores and cuttings)
DRM = Drum	SS = Surface Soil (optional use, soil < than 0.5 ft)
DW = Dry Well or French Drain	SVA = Soil Vapor - Active
GR = Grab	SVX = Soil Vapor - Passive
LYS = Lysimeter	SM = Soil Moisture
LG = Lagoon/Pond	SW = Surface Water
MW = Monitor Well	VG = Vegetation
PD = Production Well Water - Drinking (potable)	WD = Well Development
PX = Production Well Water - Non-drinking	DB = Debris
SD = Sediment	
SP = Seepage Pit	
SPR = Spring	
ST = Septic Tank	
SVS = Soil Vapor Survey	
TP = Test Pit	
TR = Trench	
WB = Wrangler Bag	

15. Mapping

Soil sample locations at the excavations will be mapped using the Global Positioning System. This will ensure that the sample locations are accurately mapped and the location data archived.

ANNEX 3-I
Risk Screening Assessment

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SWMU 228A: RISK SCREENING ASSESSMENT**I. Site Description and History**

Solid Waste Management Unit (SWMU) 228A, the Centrifuge Dump Site at Sandia National Laboratories/New Mexico (SNL/NM), covers 1.6 acres and is located about 500 feet east of Technical Area (TA)-II on land that is owned by Kirtland Air Force Base (KAFB) and leased to the U.S. Department of Energy. The site is situated on the steeply sloping northern rim of Tijeras Arroyo and the nearly flat floodplain below. Ground elevations at SWMU 228A range from 5,405 feet at the northern site boundary to about 5,360 feet at the southern site boundary on the Tijeras Arroyo floodplain.

Environmental concern about SWMU 228A was caused by weapons debris and construction debris that had been dumped at the site in the 1950s. The weapons debris, including depleted uranium (DU) fragments, came from the adjacent SWMU 50 centrifuge. Following centrifuge tests in the mid-1950s, weapons debris was dumped in a gully located about 80 feet east of the centrifuge. This gully eventually became part of SWMU 228A. The weapons debris was dumped next to construction debris that had previously been dumped in the early 1950s. The construction debris had been generated by the demolition of KAFB barracks. Except for a limited amount of cleanup in 1994, the weapons and construction debris remained near the upper end of the gully until the summer of 1997. Unfortunately, heavy rainfall on July 28, 1997, washed some of the weapons and construction debris approximately 250 feet farther down the gully and onto the Tijeras Arroyo floodplain. Starting in the summer of 1998, a voluntary corrective measure (VCM) was conducted at SWMU 228A at the four remediation areas: the construction debris area, the buried test debris area, the Scrappy-DU gully, and the Scooby-DU alluvial fan deposit. As a result of the VCM activities, all construction and weapons debris was excavated and removed.

Historical records and technical memoranda have provided a significant level of process knowledge for the centrifuge testing activities. Weapons operations at the centrifuge are well documented in a series of classified memoranda written by SNL/NM engineers and scientists. The centrifuge was constructed in 1952 within an abandoned meander-loop above the Tijeras Arroyo floodplain. The centrifuge was rocket-driven and was not covered by a building or other structure. The centrifuge was used from 1952 through 1956 to test arming, fuzing, and firing components at high rates of centrifugal acceleration. For test containment purposes, native soil was used to construct a 7-foot-high berm around the 80-foot-diameter concrete slab and to build up a nearby section of the arroyo rim. The centrifuge boom was 50 feet in length and held an experimental apparatus test jig on one end and rocket motors on the other end to provide rapid acceleration. During some tests, the test jigs contained DU and high explosive (HE) components. The most commonly used HE was 1,3,5-trinitrobenzene, also known as Cyclonite. However, none of the HE spheres or detonators were fired (expended) during the tests. DU was the only radioactive material used at the site; no other radionuclides such as tritium or plutonium were used in the centrifuge tests.

The debris at SWMU 228A consisted of weapons debris from the SWMU 50 centrifuge and construction debris from the demolition of the KAFB barracks. The weapons debris consisted mostly of DU fragments, rubber pads, aluminum pieces, concrete spheres, and small electrical components. Because SWMU 228A received weapons debris from centrifuge operations, the

potential existed for unexploded ordnance (UXO)/HE material such as rocket motors or explosives charges also to be buried in or near the Scrappy-DU gully. However, no explosive materials were found during the VCM remediation. The construction debris consisted mostly of scrap metal, lumber, bricks, and concrete rubble.

The annual precipitation for the area, as measured at the Albuquerque International Sunport, is 8.1 inches. No springs or perennial surface-water bodies are located within two miles of the site. During most rainfall events, rainfall quickly infiltrates the soil at SWMU 228A. However, virtually all of the moisture subsequently undergoes evapotranspiration. The estimates of evapotranspiration for the KAFB area range from 95 to 99 percent of the annual rainfall.

The vicinity of SWMU 228A is unpaved and no stormwater channels are used to direct surface water. The extreme southern end of SWMU 228A is located within the 100-year Tijeras Arroyo floodplain. However, the site is located approximately 800 feet from the active channel, which only flows several times each year at Powerline Road. Tijeras Arroyo is the most significant surface-water drainage feature on KAFB. The arroyo originates in Tijeras Canyon, which is bounded by the Sandia Mountains to the north and the Manzano Mountains to the south. The arroyo trends southwest along the southern edge of the site and eventually drains into the Rio Grande, approximately nine miles west of SWMU 228A.

Groundwater monitoring for the area surrounding SWMU 228A is conducted as part of the Sandia North Groundwater Investigation. Four monitoring wells (TA2-W-24, TA2-W-25, TA2-W-26, and TA2-W-27) are located within 400 feet of SWMU 228A. Two water-bearing zones, the shallow groundwater system and the regional aquifer, underlie SWMU 228A. The shallow groundwater system is not used for water supply. The depth to the shallow groundwater system is approximately 280 feet below ground surface (bgs) near the southern end of SWMU 228A. The depth to the regional aquifer is approximately 450 feet bgs. Both the City of Albuquerque and KAFB use the regional aquifer for water supply. The nearest water supply well (KAFB-11) is located approximately 0.7 mile east of SWMU 228A. The nearest downgradient water supply well is KAFB-1, which is located approximately 1.4 miles northwest of the site.

Grasslands, which include species such as blue/black grama and western wheatgrass, are the dominant plant communities surrounding SWMU 228A. The site is principally vegetated by ruderal species such as Russian thistle (tumbleweed). Soil at the site has been identified as the Bluepoint-Kokan Association. For purposes of defining the background levels of metals and radionuclides in soil, this soil has been included as part of the Sandia North Supergroup. The Bluepoint-Kokan Association consists of the Bluepoint loamy fine sand, which is developed on slopes of 5 to 15 percent, and the Kokan gravelly sand on slopes of 15 to 40 percent. These slightly calcareous soils are mildly to moderately alkaline. The runoff potential ranges from slow to very rapid, and the hazard of water erosion is slight to severe. Water permeability is moderate to very rapid. The surficial deposits are underlain by the upper unit of the Santa Fe Group, which consists of coarse- to fine-grained fluvial deposits from the ancestral Rio Grande. The Santa Fe Group intertongues with the coarse-grained alluvial fan/piedmont veneer facies that extend westward from the Sandia and Manzanita Mountains. The upper Santa Fe unit is approximately 1,200 feet thick in the vicinity of the site.

II. Data Quality Objectives

The data quality objectives (DQO) presented in the SWMU 228A VCM Plan (SNL/NM May 1998) and its accompanying SWMU 228A Field Implementation Plan (FIP) (SNL/NM July 1998) identified the site-specific confirmatory sampling locations, sample depths, sampling procedures, and analytical requirements. The DQOs outlined the quality assurance (QA)/quality control (QC) requirements necessary for producing analytical data suitable for risk-assessment purposes. The confirmatory sampling conducted at SWMU 228A was designed to:

- Confirm that a thorough remediation had been conducted during the VCM,
- Characterize the nature and extent of any residual contaminants of concern (COC),
- Demonstrate that the VCM proposed cleanup values were achieved, and
- Provide analytical data of sufficient quality to support risk screening assessments.

Table 1 summarizes the rationale for designing the sampling pattern. The source of potential COCs at SWMU 228A was the weapons debris and construction debris that had been dumped at the site in the 1950s. The VCM activities removed about 605 pounds of DU fragments along with several hundred cubic yards of weapons and construction debris.

Following the conclusion of the VCM remediation activities (excavation, debris removal, and radiological/metal detector surveying) at a particular area, a series of confirmatory soil samples was collected. The confirmatory soil samples (identified as TJAOU-228A-GR-120-S through TJAOU-228A-GR-249-S) were collected at 130 locations across SWMU 228A. All except three of the samples were surface soil samples that were collected using a hand trowel from a depth of 0 to 0.5 foot bgs. Three samples (TJAOU-228A-GR-214-S through TJAOU-228A-GR-216-S) were collected using a hand auger from a depth of 2 to 3 feet bgs. The soil samples were collected using the sampling procedures detailed in the SWMU 228A FIP (SNL/NM July 1998).

The SWMU 228A confirmatory soil samples were analyzed for all COCs: DU-related radionuclides (uranium-233/234, uranium-235, uranium-238), Resource Conservation and Recovery Act (RCRA) metals, volatile organic compounds (VOC), semivolatile organic compounds (SVOC), and HE compounds. Three analytical laboratories (Core Laboratories Inc., General Engineering Laboratories Inc. [GEL]), and the on-site SNL/NM Radiation Protection Sample Diagnostic [RPSD] Laboratory analyzed the samples. Isotopic uranium and gamma spectroscopy analyses were performed at the two off-site analytical laboratories for all 130 sample locations. Samples from approximately 50 percent of the locations also were analyzed for RCRA metals. Samples from about 20 percent of the locations were analyzed for VOCs, SVOCs, and HE compounds. Samples from approximately 35 percent of the locations were analyzed by the RPSD Laboratory for gamma emitting radionuclides. Table 2 summarizes the sampling performed to meet the data quality requirements from the SWMU 228A FIP (SNL/NM July 1998).

Nineteen QA/QC samples (nine duplicates, six trip blanks, and six equipment blanks) were collected during the confirmatory sampling effort according to the Environmental Restoration Project QA Project Plan (QAPjP). For sampling in the debris areas, duplicate soil samples were collected at 10 percent of the sampling locations. Equipment-wash (aqueous rinsate) blanks was prepared at the end of each sampling day. Trip blanks accompanied the soil samples that were sent for VOC analyses. No significant QA/QC problems were identified in the QA/QC samples.

Table 1
Summary of Sampling Performed to Meet Data Quality Objectives

SWMU 228A Sampling Areas	Potential COC Source	Number of Sampling Locations	Sample Density	Sampling Location Rationale
Construction debris area	Construction debris, including scrap metal, lumber, bricks, and concrete	10	1 per 190 ft ² ; 20-foot grid spacing and random	Confirm that no significant levels of COCs remain where construction debris was removed
Buried test debris area	Construction debris, including communication wire, scrap metal, lumber, bricks, and concrete	13	1 per 450 ft ² ; 20-foot grid spacing and random	Confirm that no significant levels of COCs remain where construction debris was removed
Scrappy-DU gully	DU fragments; weapons debris, including aluminum plates, steel brackets, nylon webbing, microelectronics, batteries; construction debris, including scrap metal, lumber, bricks, and concrete	15	1 per 80 ft ² ; 10-foot grid spacing and random	Confirm that no significant levels of COCs remain where DU fragments, construction debris, and weapons debris were removed
Scooby-DU and remainder of alluvial fan deposit	DU fragments; weapons debris, including aluminum plates, steel brackets, nylon webbing, microelectronics, batteries; construction debris, including scrap metal, lumber, bricks, and concrete	52	1 per 340 ft ² ; 25-foot grid spacing and random	Confirm that no significant levels of COCs remain where DU fragments, construction debris, and weapons debris were removed
Soil Piles #1, #2, #3	Construction debris area/buried test debris area	8	1 per 220 ft ² ; 3-foot intervals along perimeter of piles (aliquots used to make composite samples)	Confirm that no significant levels of COCs remain in soil removed from construction debris area and buried test debris area
Soil Piles #5 and #6	DU fragments	11	1 per 410 ft ² ; 10-foot intervals across Soil Pile #5 and 3-foot intervals across Soil Pile #6 (aliquots used to make composite samples)	Confirm that no significant levels of COCs remain in soil processed by the SGS or in the soil previously used as a loader (heavy equipment) ramp
Perimeter of SWMU 228A and across at SWMU 50	None suspected	21	Judgmental and random; sample density not applicable.	Confirm that no significant levels of COCs are present along perimeter of SWMU 228A and SWMU 50

COC = Contaminant of concern.

DU = Depleted uranium.

ft = Foot (feet).

SGS = Segmented Gate System.

SWMU = Solid Waste Management Unit.

Table 2
Summary of Data Quality Requirements

Analytical Requirement	Core Laboratories, Inc. and GEL	RPSD Laboratory
Gamma Spectroscopy EPA Method 901.1 ^a	130 samples	47 samples
Isotopic Uranium Laboratory Method CA-GLR-R405	130 samples	Not analyzed
RCRA metals EPA Method 6010/7000 ^a	57 samples	Not analyzed
VOCs EPA Method 8260A ^a	26 samples	Not analyzed
SVOCs EPA Method 8270 ^a	26 samples	Not analyzed
HE compounds EPA Method 8330 ^a	26 samples	Not analyzed

Note: The number of samples does not include QA/QC samples such as duplicates, trip blanks, and equipment blanks.

^aEPA November 1986.

EPA = U.S. Environmental Protection Agency.
 GEL = General Engineering Laboratories, Inc.
 HE = High explosive.
 QA = Quality assurance.
 QC = Quality control.
 RCRA = Resource Conservation and Recovery Act.
 RPSD = Radiation Protection Sample Diagnostic Laboratory.
 SVOC = Semivolatile organic compound.
 VOC = Volatile organic compound.

SNL/NM verified/validated all of the confirmatory soil sample results. The off-site laboratory results from Core Laboratories Inc. and GEL were reviewed according to "Data Verification/Validation Level 3—DV-3" in the Technical Operating Procedure 94-03, Rev. 0. The DV3 reports are presented in the associated SWMU 228A no-further-action (NFA) proposal. The gamma spectroscopy data from the RPSD Laboratory were reviewed according to "Laboratory Data Review Guidelines," Procedure No. RPSD-02-11, Issue No. 02. The RPSD verification/validation reports are presented with the gamma spectroscopy results in the NFA proposal. The reviews confirmed that the analytical data from the three analytical laboratories were acceptable for use in the NFA proposal.

III. Determination of Nature, Rate, and Extent of Contamination

III.1 Introduction

The determination of the nature, migration rate, and extent of contamination at SWMU 228A was based upon an initial conceptual model validated with confirmatory sampling at the site.

The initial conceptual model was developed from archival research, soil sampling, soil-vapor sampling, aerial photographs, geophysical surveys, and radiological surveys. The DQOs contained in the SWMU 228A VCM Plan and its FIP identified the sample locations, sample density, sample depth, and analytical requirements. The sample data were subsequently used to develop the final conceptual model for SWMU 228A, which is presented in Section 3.5 of the associated NFA proposal. The nature, migration rate, and extent of contamination is described below.

III.2 Nature of Contamination

Both the nature of contamination and the potential for the degradation of COCs at SWMU 228A was evaluated using laboratory analyses of the soil samples (Section V). The analytical requirements included gamma spectroscopy and specific analyses for DU-related radionuclides, RCRA metals, VOCs, SVOCs, and HE. The analyses characterized any potential contaminants remaining after the debris removal operation. The analytes and methods listed in Table 2 were appropriate to characterize the COCs and degradation products at SWMU 228A.

III.3 Rate of Contaminant Migration

SWMU 228A is an inactive site that has been recently remediated, and therefore, all primary sources of COCs have been eliminated. As a result, only secondary sources of COCs potentially remain in soil in the form of adsorbed COCs (DU, RCRA metals, VOCs, SVOCs, and HE). The rate of COC migration from surficial soil is dependent predominantly upon precipitation and occasional surface-water flow, as described in Section V. Data available from the Sandia North Groundwater Investigation; numerous SNL/NM monitoring programs for air, water, and radionuclides; various biological surveys; and meteorological monitoring are adequate to evaluate the rate of COC migration at SWMU 228A.

III.4 Extent of Contamination

Surface and subsurface confirmatory soil samples were collected from all four of the remediated areas and the vicinity of SWMU 228A to assess the effectiveness of the VCM remediation. The confirmatory soil samples were collected using the sampling density in Table 1 after the following five VCM excavation targets were satisfied:

1. No visible DU fragments, construction debris, or weapons debris remained.
2. Verification radiological surveys with field instruments indicated that no DU fragments or DU-contaminated soil with radioactivity in excess of 1.3 times background were present.
3. Verification geophysical surveys indicated that no debris remained buried.
4. No VOCs or SVOCs were detected with the photoionization detector.
5. Geologic evidence was found that distinguished fill material from native soil.

Confirmatory soil samples were collected from the ground surface to a maximum depth of 3 feet. Sampling at a more extensive variety of depths was not a significant concern at SWMU 228A because the five VCM excavation targets were satisfied. Furthermore, the vertical rate of contamination migration was expected to be extremely low for SWMU 228A because of the low precipitation, high evapotranspiration, impermeable vadose zone soils, and the relatively low solubility of metals and DU. Therefore, the confirmatory soil samples are considered to be both representative of the soil potentially contaminated with the COCs and sufficient to determine the vertical extent, if any, of COCs.

In summary, the design of the confirmatory sampling was appropriate and adequate to determine the nature, migration rate, and extent of residual COCs in surface and subsurface soils at SWMU 228A.

IV. Comparison of COCs to Background Screening Levels

Site history and characterization activities were used to identify potential COCs. The identification of COCs and the sampling to determine the residual concentration levels of those COCs across the site are described in the SWMU 228A NFA proposal. Generally, COCs evaluated in this risk assessment include all detected radiological COCs and organics and all inorganic COCs for which samples were analyzed. In order to provide conservatism in this risk assessment, the calculation uses only the maximum concentration value of each COC determined for the entire site. The SNL/NM maximum background concentration (Dinwiddie September 1997) was selected to provide the background screening results shown in Tables 3 and 4. If applicable, human health nonradiological COCs were also compared to SNL/NM-proposed Subpart S action levels (Table 3) (IT July 1994). Nonradiological inorganics that are essential nutrients such as iron, magnesium, calcium, potassium, and sodium are not included in this risk assessment (EPA 1989).

Table 3 lists nonradiological COCs for the human health and ecological risk assessment at SWMU 228A; Table 4 lists radiological COCs. Both tables show the associated SNL/NM maximum background concentration values (Dinwiddie September 1997). Sections VI.4, VII.2 and VII.3 discuss the content of Tables 3 and 4.

V. Fate and Transport

The primary releases of COCs at SWMU 228A were to the ground surface in association with the surface disposal of waste material along a gully near the old centrifuge site (SWMU 50), approximately 500 feet east of the historic boundary for TA-II along the northern rim of the Tijeras Arroyo. Subsequent erosion by surface-water runoff exposed some of the debris and carried COCs southward toward the main channel of the Tijeras Arroyo with the transported soil. Residual COCs in the exposed soil may be transported by certain winds, although the site is somewhat protected by topography and reseeded native grasses.

The average annual precipitation received at this site is about 8 inches (NOAA 1990). Most of the water received at the site will infiltrate into the soil and will then be lost to evapotranspiration. Water that infiltrates into the soil may carry COCs desorbed from the soil particles. The COCs at this site generally do not have a high potential for leaching in soil.

Table 3
Nonradiological COCs for Human Health and Ecological Risk Assessment at SWMU 228A with Comparison to the Associated SNL/NM Background Screening Value, BCF and Log K_{ow}

COC Name	Maximum Concentration (mg/kg)	SNL/NM Background Concentration (mg/kg) ^a	Is Maximum COC Concentration Less Than or Equal to the Applicable SNL/NM Background Screening Value?	BCF (maximum aquatic)	Log K _{ow} (for organic COCs)	Bioaccumulator? ^b (BCF>40, log K _{ow} >4)
Arsenic	3.32	4.4	Yes	44 ^c	NA	Yes
Barium	216	200	No	170 ^d	NA	Yes
Cadmium	1.77	<1	No	64 ^c	NA	Yes
Chromium, total	12.0	12.8	Yes	16 ^c	NA	No
Lead	40.5	11.2	No	49 ^c	NA	Yes
Mercury	0.063 J	<0.1	Unknown	5500 ^c	NA	Yes
Selenium	0.918	<1	Unknown	800 ^e	NA	Yes
Silver	0.436 J	<1	Unknown	0.5 ^c	NA	No
Uranium	83.9	2.3	No	20 ^d	NA	No
Benzene	0.0012	NA	NA	5.2 ^c	2.13 ^c	No
Methylene chloride	0.0072	NA	NA	5 ^f	1.25 ^f	No
Acenaphthene	0.070 J	NA	NA	389 ^g	3.92 ^g	Yes
Anthracene	0.110 J	NA	NA	917 ^c	4.45 ^c	Yes
Benzo(a)anthracene	0.32 J	NA	NA	10,000 ^g	5.61 ^g	Yes
Benzo(a)pyrene	0.26 J	NA	NA	3,000 ^c	6.04 ^c	Yes
Benzo(b)fluoranthene	0.37	NA	NA	--	6.124 ^g	Yes
Benzo(g,h,i)perylene	0.25 J	NA	NA	58,884 ^g	6.58 ^g	Yes
Benzo(k)fluoranthene	0.28 J	NA	NA	93,325 ^g	6.84 ^g	Yes
Chrysene	0.37	NA	NA	18,000 ^g	5.91 ^g	Yes
Di-n-butyl phthalate	0.06 J	NA	NA	6,761 ^h	4.61 ^g	Yes
bis(2-ethylhexyl) phthalate	0.11 J	NA	NA	851 ^h	7.6 ^g	Yes

Refer to footnotes at end of table.

Table 3 (Concluded)
Nonradiological COCs for Human Health and Ecological Risk Assessment at SWMU 228A with Comparison to the Associated SNL/NM Background Screening Value, BCF and Log K_{ow}

COC Name	Maximum Concentration (mg/kg)	SNL/NM Background Concentration (mg/kg) ^a	Is Maximum COC Concentration Less Than or Equal to the Applicable SNL/NM Background Screening Value?	BCF (maximum aquatic)	Log K_{ow} (for organic COCs)	Bioaccumulator? ^b (BCF>40, log K_{ow} >4)
Fluoranthene	0.63	NA	NA	12,302 ^g	4.90 ^g	Yes
Fluorene	0.050 J	NA	NA	2,239 ^g	4.18 ^g	Yes
Indeno(1,2,3-c,d)pyrene	0.099 J	NA	NA	59,407 ^g	6.58 ^g	Yes
Phenanthrene	0.42	NA	NA	23,800 ^c	4.63 ^c	Yes
Pyrene	0.6	NA	NA	36,300 ^c	5.32 ^g	Yes

Note: **Bold** indicates the COCs that failed the background screening procedure and/or are bioaccumulators.

^aFrom Dinwiddie (September 1997) North Supergroup.

^bNMED (March 1998).

^cBCF and/or Log K_{ow} from Yanicak (March 1997).

^dBCF from Neumann (1976).

^eBCF from Callahan et al. (1979).

^fBCF and/or Log K_{ow} from Howard (1990).

^gBCF and/or Log K_{ow} from Micromedex (1998).

^hBCF from Howard (1989).

BCF = Bioconcentration factor.

COC = Constituent of concern.

J = Estimated concentration.

K_{ow} = Octanol-water partition coefficient.

Log = Logarithm (base 10).

mg/kg = Milligram(s) per kilogram.

NA = Not applicable.

NMED = New Mexico Environment Department.

SNL/NM = Sandia National Laboratories/New Mexico.

SWMU = Solid Waste Management Unit.

-- = Information not available.

Table 4
Radiological COCs for Human Health and Ecological Risk Assessment at SWMU 228A with Comparison to the Associated SNL/NM Background Screening Value and BCF

COC Name	Maximum Concentration (pCi/g)	SNL/NM Background Concentration (pCi/g) ^a	Is Maximum COC Concentration Less Than or Equal to the Applicable SNL/NM Background Screening Value?	BCF (maximum aquatic)	Bioaccumulator? ^b (BCF>40)
Cs-137	0.621	0.836	Yes	3000 ^c	Yes
Th-232	1.24	1.54	Yes	3000 ^d	No ^e
U-233/234	1.64	1.6	No	900 ^d	Yes
U-235	0.8	0.18	No	900 ^d	Yes
U-238	11.4	1.3	No	900 ^d	Yes

Note: **Bold** indicates the COCs that failed the background screening procedure and/or are bioaccumulators.

^aFrom Dinwiddie (September 1997), North Supergroup.

^bNMED (March 1998).

^cFrom Whicker and Schultz (1982).

^dFrom Baker and Soldat (1992).

^eFrom Yanicak (March 1997).

BCF = Bioconcentration factor.

COC = Constituent of concern.

NMED = New Mexico Environment Department.

pCi/g = Picocurie(s) per gram.

SNL/NM = Sandia National Laboratories/New Mexico.

SWMU = Solid Waste Management Unit.

Because groundwater at SWMU 228A is approximately 280 feet bgs, it is unlikely that the infiltration and percolation at the site will be sufficient to reach groundwater. The potential for future surface-water runoff and run on has been extensively mitigated. Final grading at the northern part of SWMU 228A and around the SWMU 50 centrifuge has eliminated the catch basin that created the July 1997 erosion and washout of debris. Surface-water controls (a diversion ditch, revegetation, and erosion-control mats) have greatly reduced the effects of surface water. Numerous site inspections during the unusually wet August 1999, monsoon season confirm that no off-site surface water runoff or run on occurs at SWMU 228A; the rainfall infiltrated the soil well before off-site runoff or run on could occur. Transported soils have not left the site or reached the active channel of the Tijeras Arroyo, which is located about 800 feet south of the site across the flat floodplain.

The site contains natural vegetation and is open for use by wildlife. Therefore, uptake of COCs into the food chain is possible. Plant roots can take up constituents of potential ecological concern (COPEC) from the soil, and these can be either transferred to herbivores that consume the plant tissues or returned to the soil as litter. Above-ground litter could be transported by wind and surface water until consumed by decomposer organisms. Animals could also consume COCs through direct ingestion of soil particles. COCs that are consumed by animals could pass through the gut and be returned to the soil in feces (either at the site or distant from the site as the animal moves), or they could be absorbed into tissues and held. The animal could be eaten by a carnivore or scavenger, and the constituents still held in the consumed tissues would repeat the process of excretion or consumption by higher predators, scavengers, and decomposers.

The residual COCs at SWMU 228A include both inorganic and organic constituents. The inorganic COCs (including radionuclides) are elemental in form, and therefore, they are not considered to be degradable. Transformations of inorganics may include changes in valence (oxidation/reduction reactions) or incorporation into organic forms (e.g., the conversion of selenite or selenate from soil to seleno-amino acids in plants). This is often the result of biotransformation (i.e., transformation caused by plants, animals, and microorganisms); however, because of the aridity of the environment, such processes are not expected to be significant at this site. Because of their long half-lives, loss of radionuclides by radioactive decay is also considered to be insignificant at this site. Transformation of organic compounds through photolysis, hydrolysis, and biodegradation may occur but it is expected that the aridity of the environment would slow the process. Loss by volatilization may occur for those organics near the soil surface, especially for benzene and methylene chloride.

Table 5 summarizes the fate and transport processes that may occur at SWMU 228A. Because of the topography and vegetative cover at this site, the potential for transport by wind is low. The potential for transport by surface water is low and is not expected to result in significant off-site effects. The existence of natural vegetative cover and habitat for wildlife at this site results in a potential for food chain uptake; however, because of the site's small size and arid conditions, this is not expected to be a significant fate and transport mechanism for COCs. COCs are not expected to leach significantly into the soil and are, therefore, not expected to reach groundwater. Degradation or transformation of the inorganic COCs at this site is expected to be negligible but may affect some of the organic COCs present at the site.

Table 5
Summary of Fate and Transport at SWMU 228A

Transport and Fate Mechanism	Existence at Site	Significance
Wind	Yes	Low
Surface runoff	Yes	Low
Migration to groundwater	No	None
Food chain uptake	Yes	Low
Transformation/degradation	Yes	Low

SWMU = Solid Waste Management Unit.

VI. Human Health Risk Screening Assessment

VI.1 Introduction

Human health risk screening assessment of this site includes a number of steps that culminate in a quantitative evaluation of the potential adverse human health effects caused by constituents located at the site. The steps to be discussed include the following:

Step 1. Site data are described that provide information on the potential COCs, as well as the relevant physical characteristics and properties of the site.
Step 2. Potential pathways are identified by which a representative population might be exposed to the COCs.
Step 3. The potential intake of these COCs by the representative population is calculated using a tiered approach. The first component of the tiered approach includes two screening procedures. One screening procedure compares the maximum concentration of the COC to an SNL/NM maximum background screening value. COCs that are not eliminated during the first screening procedure are subjected to a second screening procedure that compares the maximum concentration of the COC to the SNL/NM proposed Subpart S action level.
Step 4. Toxicological parameters are identified and referenced for COCs that were not eliminated during the screening steps.
Step 5. Potential toxicity effects (specified as a hazard index [HI]) and excess cancer risks are calculated for nonradiological COCs and background. For radiological COCs, the incremental total effective dose equivalent (TEDE) and incremental estimated cancer risk are calculated by subtracting applicable background concentrations directly from maximum on-site contaminant values. This background subtraction only occurs when a radiological COC occurs as contamination and exists as a natural background radionuclide.
Step 6. These values are compared with guidelines established by the EPA and U.S. Department of Energy (DOE) to determine if further evaluation, and potential site clean-up, is required. Nonradiological COC risk values are also compared to background risk so that an incremental risk may be calculated.
Step 7. Uncertainties regarding the contents of the previous steps are addressed.

VI.2 Step 1. Site Data

Section I provides the description and history for SWMU 228A. Section II presents the argument that DQOs were satisfied. Section III describes the determination of the nature, rate, and extent of contamination.

VI.3 Step 2. Pathway Identification

SWMU 228A has been designated with a future land-use scenario of industrial (DOE et al. September 1995) (see Appendix 1 for default exposure pathways and parameters). Because of the location and the characteristics of the potential contaminants, the primary pathway for human exposure is considered to be soil ingestion for the nonradiological COCs and direct gamma exposure for the radiological COCs. The inhalation pathway for both nonradiological and radiological COCs is included because of the potential to inhale dust and volatiles (volatile inhalation is limited to nonradiological COCs). Soil ingestion is included for the radiological COCs as well. No water pathways to the groundwater are considered, because depth to groundwater at SWMU 228A is approximately 280 feet bgs. Because of the lack of surface water or other significant mechanisms for dermal contact, the dermal exposure pathway is considered to be insignificant. No intake routes through plant, meat, or milk ingestion are considered appropriate for the industrial land-use scenario. However, plant uptake is considered for the residential land-use scenario.

Pathway Identification

Nonradiological Constituents	Radiological Constituents
Soil ingestion	Soil ingestion
Inhalation (dust and volatiles)	Inhalation (dust)
Plant uptake (residential only)	Plant uptake (residential only)
	Direct gamma

VI.4 Step 3. COC Screening Procedures

This section discusses Step 3, which includes the two screening procedures. The first screening procedure compared the maximum COC concentration to the background screening level. The second screening procedure compared maximum COC concentrations to SNL/NM proposed Subpart S action levels. This second procedure was applied only to COCs that were not eliminated during the first screening procedure.

VI.4.1 Background Screening Procedure

VI.4.1.1 Methodology

Maximum concentrations of nonradiological COCs were compared to the approved SNL/NM maximum screening level for this area. The SNL/NM maximum background concentration was selected to provide the background screen in Table 3 and was used to calculate risk attributable to background in Table 9. Only the COCs that were above their respective SNL/NM maximum background screening levels or did not have a quantifiable background screening level were considered in further risk assessment analyses.

For radiological COCs that exceeded the SNL/NM background screening levels, background values were subtracted from the individual maximum radionuclide concentrations. Those that

did not exceed these background levels were not carried any further in the risk assessment. This approach is consistent with DOE (1993). Radiological COCs that did not have a background value and were detected above the analytical minimum detectable activity were carried through the risk assessment at their maximum levels. The resultant radiological COCs remaining after this step are referred to as background-adjusted radiological COCs.

VI.4.1.2 Background Screening Procedure Results

A comparison of SWMU 228A maximum COC concentrations to the SNL/NM maximum background values (Dinwiddie September 1997) for the human health risk assessment is presented in Tables 3 and 4. For the nonradiological COCs, four constituents exceeded the background screening value. Three COCs had no quantified background screening levels; thus, it is unknown whether these COCs exceeded background. Finally, seventeen COCs were organic and had no background screening values.

The maximum concentration value for lead is 40.5 milligrams (mg)/kilogram (kg). The EPA intentionally does not provide any human health toxicological data on lead; therefore, no risk parameter values could be calculated. However, EPA Region 6 guidance for the screening value for lead for the industrial land-use scenario is 2,000 mg/kg (EPA 1996a); for the residential land-use scenario, the EPA screening guidance value is 400 mg/kg (EPA July 1994). The maximum concentration value for lead at this site is less than both screening values; therefore, lead is eliminated from further consideration in the human health risk assessment.

For the radiological COCs, three constituents had maximum activity concentrations greater than their respective background (uranium-233/234, uranium-235, and uranium-238).

VI.4.2 Subpart S Screening Procedure

VI.4.2.1 Methodology

The maximum concentrations of nonradiological COCs not eliminated during the background screening process were compared with action levels (IT July 1994) that were calculated using methods and equations promulgated in the proposed RCRA Subpart S (EPA 1990) and Risk Assessment Guidance for Superfund (RAGS) (EPA 1989) documentation. Accordingly, all calculations were based upon the assumption that receptor doses from both toxic and potentially carcinogenic compounds result most significantly from ingestion of contaminated soil. Because the samples were all taken from the surface, this assumption is considered valid. If there were ten or fewer COCs and each had a maximum concentration less than one-tenth the action level, then the site was judged to pose no significant health hazard to humans. If there were more than ten COCs, the Subpart S screening procedure was not performed.

VI.4.2.2 Results

Because the SWMU 228A sample set had more than ten COCs that continued beyond the first screening level (including COCs that did not have background screening values), the proposed

Subpart S screening process was not performed. All nonradiological COCs that were not eliminated during the background screening process for SWMU 228A had a calculated hazard quotient (HQ) and excess cancer risk value.

Radiological COCs have no predetermined action levels analogous to proposed Subpart S levels, and therefore, this step in the screening process is not performed for radiological COCs.

VI.5 Step 4. Identification of Toxicological Parameters

Tables 6 (nonradiological) and 7 (radiological) show the COCs retained in the risk assessment and the values for the available toxicological information. The toxicological values used for nonradiological COCs in Table 6 were taken from the Integrated Risk Information System (IRIS) (EPA 1998a), the Health Effects Assessment Summary Tables (HEAST) (EPA 1997a), and the Region 9 (EPA 1996b) electronic database. Dose conversion factors (DCF) used in determining the excess TEDE values for radiological COCs for the individual pathways were the default values provided in the RESRAD computer code (Yu et al. 1993a) as developed in the following documents:

- DCFs for ingestion and inhalation were taken from "Federal Guidance Report No. 11, Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion" (EPA 1988).
- DCFs for surface contamination (contamination on the surface of the site) were taken from DOE/EH-0070, "External Dose-Rate Conversion Factors for Calculation of Dose to the Public" (DOE 1988).
- DCFs for volume contamination (exposure to contamination deeper than the immediate surface of the site) were calculated using the methods discussed in "Dose-Rate Conversion Factors for External Exposure to Photon Emitters in Soil" (Kocher 1983) and in ANL/EAIS-8, *Data Collection Handbook to Support Modeling the Impacts of Radioactive Material in Soil* (Yu et al. 1993b).

VI.6 Step 5. Exposure Assessment and Risk Characterization

Section VI.6.1 describes the exposure assessment for this risk assessment. Section VI.6.2 provides the risk characterization, including the HI and the excess cancer risk, for both the potential nonradiological COCs and associated background for industrial and residential land uses. The incremental TEDE and incremental estimated cancer risk are provided for the background-adjusted radiological COCs for both industrial and residential land uses.

VI.6.1 Exposure Assessment

Appendix 1 shows the equations and parameter input values used in calculating intake values and subsequent HI and excess cancer risk values for the individual exposure pathways. The appendix shows parameters for both the industrial and residential land-use scenarios. The equations for nonradiological COCs are based upon the RAGS (EPA 1989). Parameters are

Table 6
Toxicological Parameter Values for SWMU 228A Nonradiological COCs

COC Name	RfD _o (mg/kg-day)	Confidence ^a	RfD _{inh} (mg/kg-day)	Confidence ^a	SF _o (mg/kg-day) ⁻¹	SF _{inh} (mg/kg-day) ⁻¹	Cancer Class ^b
Barium	7E-2 ^c	M	1.4E-4 ^d	--	--	--	--
Cadmium	5E-4 ^c	H	5.7E-5 ^d	--	--	6.3E+0 ^e	B1
Mercury	3E-4 ^a	--	8.6E-5 ^c	M	--	--	D
Selenium	5E-3 ^c	H	--	--	--	--	D
Silver	5E-3 ^c	L	--	--	--	--	D
Uranium	3E-3 ^c	M	--	--	--	--	--
Benzene	1.7E-3 ^d	--	1.7E-3 ^d	--	2.9E-2 ^c	2.9E-2 ^c	A
Methylene chloride	6E-2 ^c	M	8.6E-1 ^a	--	7.5E-3 ^c	1.7E-3 ^c	B2
Acenaphthene	6E-2 ^c	L	6E-2 ^d	--	--	--	--
Anthracene	3E-1 ^c	L	3E-1 ^d	--	--	--	D
Benzo(a)anthracene	--	--	--	--	7.3E-1 ^d	7.3E-1 ^d	--
Benzo(a)pyrene	--	--	--	--	7.3E+0 ^c	7.3E+0 ^d	B2
Benzo(b)fluoranthene	--	--	--	--	7.3E-1 ^d	7.3E-1 ^c	B2
Benzo(g,h,i)perylene ^e	--	--	--	--	7.3E+0 ^d	7.3E+0 ^d	B2
Benzo(k)fluoranthene	--	--	--	--	7.3E-2 ^d	7.3E-2 ^d	B2
Chrysene	--	--	--	--	7.3E-3 ^d	7.3E-3 ^d	B2
Di-n-butyl phthalate	1E-1 ^c	L	1E-1 ^d	--	--	--	D
bis(2-ethylhexyl) phthalate	2E-2 ^d	--	2.2E-2 ^c	--	1.4E-2 ^d	1.4E-2 ^d	--
Fluoranthene	4E-2 ^c	L	4E-2 ^d	--	--	--	D
Fluorene	4E-2 ^c	L	4E-2 ^d	--	--	--	D
Indeno(1,2,3-c,d)pyrene	--	--	--	--	7.3E-1 ^c	7.3E-1 ^d	B2
Phenanthrene ^e	3E-1 ^c	L	3E-1 ^d	--	--	--	D
Pyrene	3E-2 ^c	L	3E-2 ^d	--	--	--	D

^aConfidence associated with IRIS (EPA 1998a) database values. Confidence - L = low, M = medium, H = high.

^bEPA weight-of-evidence classification system for carcinogenicity (EPA 1989) taken from IRIS (EPA 1998a):

A = Human carcinogen.

B1 = Probable human carcinogen. Limited human data are available.

B2 = Probable human carcinogen. Indicates sufficient evidence in animals and inadequate or no evidence in humans.

D = Not classifiable as to human carcinogenicity.

^cToxicological parameter values from IRIS electronic database (EPA 1998a).

^dToxicological parameter values from EPA Region 9 electronic database (EPA 1996b)

^eToxicological parameter values from HEAST database (EPA 1997a)

^fToxicological parameter values for benzo(g,h,i)perylene were not found in toxicological databases; Dibenzo(a,h)anthracene was selected as surrogate compound.

^gToxicological parameter values for phenanthrene were not found in toxicological databases. Anthracene was selected as surrogate compound.

COC = Constituent of concern.

EPA = U.S. Environmental Protection Agency.

HEAST = Health Effects Assessment Summary Tables.

Table 6 (Concluded)
Toxicological Parameter Values for SWMU 228A Nonradiological COCs

IRIS = Integrated Risk Information System.
 mg/kg-day = Milligram(s) per kilogram day.
 (mg/kg-day)⁻¹ = Per milligram per kilogram day.
 RfD_{inh} = Inhalation chronic reference dose.
 RfD_o = Oral chronic reference dose.
 SF_{inh} = Inhalation slope factor.
 SF_o = Oral slope factor.
 SWMU = Solid Waste Management Unit.
 -- = Information not available.

Table 7
Radiological Toxicological Parameter Values for SWMU 228A COCs Obtained from RESRAD Risk Coefficients^a

COC Name	SF _o (1/pCi)	SF _{inh} (1/pCi)	SF _{ev} (g/pCi-yr)	Cancer Class ^b
U-233/234	4.40E-11	1.40E-08	2.10E-11	A
U-235	4.70E-11	1.30E-08	2.70E-07	A
U-238	6.20E-11	1.20E-08	6.60E-08	A

^aFrom Yu et al. (1993a).

^bEPA weight-of-evidence classification system for carcinogenicity (EPA 1989): A = Human carcinogen.

1/pCi = One per picocurie.

COC = Constituent of concern.

EPA = U.S. Environmental Protection Agency.

g/pCi-yr = Gram(s) per picocurie-year.

SF_{ev} = External volume exposure slope factor.

SF_{inh} = Inhalation slope factor.

SF_o = Oral (ingestion) slope factor.

SWMU = Solid Waste Management Unit.

based upon information from the RAGS (EPA 1989) and other EPA guidance documents and reflect the reasonable maximum exposure (RME) approach advocated by the RAGS (EPA 1989). For radiological COCs, the coded equations provided in RESRAD computer code were used to estimate the incremental TEDE and cancer risk for individual exposure pathways. Further discussion of this process is provided in the *Manual for Implementing Residual Radioactive Material Guidelines Using RESRAD* (Yu et al. 1993a).

Although the designated land-use scenario is industrial for this site, risk and TEDE values for a residential land-use scenario are also presented. These residential risk and TEDE values are presented only to provide perspective on potential risk to human health under the more restrictive land-use scenario.

VI.6.2 Risk Characterization

Table 8 shows an HI of 0.03 for the SWMU 228A nonradiological COCs and an excess cancer risk of $2\text{E-}6$ for the designated industrial land-use scenario. The numbers presented included exposure from soil ingestion, and dust and volatile inhalation for nonradiological COCs. Table 9 shows that the associated background constituents had an HI of 0.00 and no measurable excess cancer risk.

For the radiological COCs, contribution from the direct gamma exposure pathway is included. For the industrial land-use scenario, a TEDE was calculated for an individual who spends 4 hours/week on the site. This resulted in an incremental TEDE of $7.0\text{E-}1$ millirem (mrem) per year (/yr). In accordance with EPA guidance found in Office of Solid Waste and Emergency Response Directive No. 9200.4-18 (EPA 1997b), an incremental TEDE of 15 mrem/yr was used for the probable land-use scenario (industrial in this case); the calculated dose value for SWMU 228A for the industrial land use was well below this guideline. The estimated excess cancer risk was $7.8\text{E-}6$.

For the residential land-use scenario nonradioactive COCs, the HI was 2 and the excess cancer risk was $2\text{E-}5$ (Table 8). The numbers in the table included exposure from soil ingestion, dust and volatile inhalation, and plant uptake. Although the EPA (EPA 1991) generally recommends that inhalation not be included in a residential land-use scenario, this pathway was included because of the potential for soil in Albuquerque, New Mexico, to be eroded and, subsequently, for dust to be present in predominantly residential areas. Because of the nature of the local soil, other exposure pathways were not considered (see Appendix 1). Table 9 shows that the associated background constituents had a HI of 0.04 and no measurable excess cancer risk.

For the radiological COCs, the incremental TEDE for the residential land-use scenario was $2.7\text{E+}0$ mrem/yr. The guideline being used was an excess TEDE of 75 mrem/yr (SNL/NM February 1998) for a complete loss of institutional controls (residential land use in this case); the calculated dose value for SWMU 228A for the residential land-use scenario was well below this guideline. Consequently, SWMU 228A is eligible for unrestricted radiological release because the residential land-use scenario resulted in an incremental TEDE of less than 75 mrem/yr to the on-site receptor. The estimated excess cancer risk was $2.5\text{E-}5$. The excess cancer risk from the nonradiological COCs and the radiological COCs is not additive, as noted in the RAGS (EPA 1989).

VI.7 Step 6. Comparison of Risk Values to Numerical Guidelines.

The human health risk assessment analysis evaluated the potential for adverse health effects for both an industrial land-use scenario (the designated land-use scenario for this site) and a residential land-use scenario.

For the industrial land-use scenario nonradiological COCs, the HI calculated was 0.03 (less than the numerical guideline of 1 suggested in the RAGS [EPA 1989]). Excess cancer risk was estimated at $2\text{E-}6$. Guidance from the New Mexico Environment Department (NMED) indicates that excess lifetime risk of developing cancer by an individual must be less than $1\text{E-}6$ for Class A and B carcinogens and less than $1\text{E-}5$ for Class C carcinogens (NMED March 1998). For this

Table 8
Risk Assessment Values for SWMU 228A Nonradiological COCs

COC Name	Maximum Concentration (mg/kg)	Industrial Land-Use Scenario ^a		Residential Land-Use Scenario ^a	
		Hazard Index	Cancer Risk	Hazard Index	Cancer Risk
Barium	216	0.00	--	0.03	--
Cadmium	1.77	0.00	6E-10	1.45	1E-9
Mercury	0.063 J	0.00	--	0.11	--
Selenium	0.918	0.00	--	0.32	--
Silver	0.436 J	0.00	--	0.02	--
Uranium	83.9	0.03	--	0.20	--
Benzene	0.0012	0.00	9E-10	0.00	1E-8
Methylene chloride	0.0072	0.00	5E-10	0.00	5E-8
Acenaphthene	0.070 J	0.00	--	0.00	--
Anthracene	0.110 J	0.00	--	0.00	--
Benzo(a) anthracene	0.32 J	0.00	8E-8	0.00	1E-6
Benzo(a) pyrene	0.26 J	0.00	7E-7	0.00	6E-6
Benzo(b) fluoranthene	0.37	0.00	1E-7	0.00	9E-7
Benzo(g,h,i) perylene ^b	0.25 J	0.00	6E-7	0.00	9E-6
Benzo(k) fluoranthene	0.28 J	0.00	7E-9	0.00	7E-8
Chrysene	0.37	0.00	1E-9	0.00	1E-8
Di-n-butyl phthalate	0.06 J	0.00	--	0.00	--
bis (2-ethylhexyl) phthalate	0.11 J	0.00	5E-10	0.00	4E-9
Fluoranthene	0.63	0.00	--	0.00	--
Fluorene	0.050 J	0.00	--	0.00	--
Indeno(1,2,3-c,d) pyrene	0.099 J	0.00	3E-8	0.00	2E-7
Phenanthrene ^c	0.42	0.00	--	0.00	--
Pyrene	0.6	0.00	--	0.00	--
Total		0.03	2E-6	2	2E-5

^aFrom EPA (1989).

^bToxicological parameter values for benzo(g,h,i) perylene were not found in toxicological databases. Dibenz(a,h) anthracene was selected as surrogate compound.

^cToxicological parameter values for phenanthrene were not found in toxicological databases. Anthracene was selected as surrogate compound.

EPA = U.S. Environmental Protection Agency.

COC = Constituent of concern.

J = Concentration is estimated.

mg/kg = Milligram(s) per kilogram.

SWMU = Solid Waste Management Unit.

-- = Information not available.

Table 9
Risk Assessment Values for SWMU 228A Nonradiological Background Constituents

COC Name	Background Concentration ^a (mg/kg)	Industrial Land-Use Scenario ^b		Residential Land-Use Scenario ^b	
		Hazard Index	Cancer Risk	Hazard Index	Cancer Risk
Barium	200	0.00	--	0.03	--
Cadmium	<1	--	--	--	--
Mercury	<0.1	--	--	--	--
Selenium	<1	--	--	--	--
Silver	<1	--	--	--	--
Uranium	2.3	0.00	--	0.01	--
Total		0.00	--	0.04	--

^aFrom Dinwiddie (September 1997), North Supergroup.

^bFrom EPA (1989).

COC = Constituent of concern.

EPA = U.S. Environmental Protection Agency.

mg/kg = Milligram(s) per kilogram.

SWMU = Solid Waste Management Unit.

-- = Information not available.

assessment, the excess cancer risk was driven by benzo(a)pyrene, benzo(b) fluoranthene, and benzo(g,h,i) perylene. All three of these organics are Class B2 carcinogens. Thus, the excess cancer risk for this site was above the suggested acceptable risk value (1E-6).

This assessment also determined risks considering background concentrations of the potential nonradiological COCs for both the industrial and residential land-use scenarios. Table 9 shows that the associated background constituents had an HI of 0.00 and no measurable excess cancer risk. Incremental risk was determined by subtracting risk associated with background from potential COC risk. These numbers were not rounded before the difference was determined and, therefore, may appear to be inconsistent with numbers presented in tables and within the text. For conservatism, the background constituents that do not have quantified background concentrations are assumed to have an HQ and excess cancer risk of 0.00. Incremental HI was 0.03. Incremental cancer risk was 1.52E-6 for the industrial land-use scenario. These incremental risk calculations indicated incremental excess cancer risk above the proposed guidelines, considering a industrial land-use scenario.

For radiological COCs and the industrial land-use scenario, incremental TEDE was 7.0E-1 mrem/yr, which is significantly less than EPA's numerical guideline of 15 mrem/yr. Incremental estimated excess cancer risk was 7.8E-6.

The calculated HI for the residential land-use scenario nonradiological COCs was 2, which is above the numerical guidance. Excess cancer risk was estimated at 2E-5. Excess cancer risk was driven by benzo(a) pyrene, benzo(b) fluoranthene, and benzo(g,h,i) perylene. All three organics are Class B2 carcinogens. Therefore, the excess cancer risk for this site would be above the suggested acceptable risk value (1E-6). Table 9 shows that the associated background constituents had an HI of 0.04 and no measurable excess cancer risk. The

incremental HI was 2.09, and the incremental cancer risk was $1.72\text{E-}5$ for the residential land-use scenario. Both the incremental HI and excess cancer risk were above proposed guidelines considering the residential land-use scenario.

The incremental TEDE for a residential land-use scenario from the radiological components was $2.7\text{E}+0$ mrem/yr, which is significantly less than the numerical guideline of 75 mrem/yr suggested in the SNL/NM RESRAD Input Parameter Assumptions and Justification (SNL/NM February 1998). The estimated excess cancer risk was $2.5\text{E-}5$.

VI.8 Step 7. Uncertainty Discussion

The determination of the nature, rate, and extent of contamination at SWMU 228A was based upon an initial conceptual model that was validated with confirmatory sampling conducted across the site. The confirmatory sampling was implemented in accordance with the SWMU 228A VCM Plan (SNL/NM May 1998) and the SWMU 228A FIP (SNL/NM July 1998). The DQOs contained in the VCM Plan and the FIP were appropriate for use in risk-screening assessments. The data collected, based upon sample location, density, and depth, were representative of the site. The analytical requirements and results satisfied the DQOs. Data quality was verified/validated in accordance with SNL/NM procedures (SNL/NM July 1994, SNL/NM July 1996). Therefore, there is no uncertainty associated with the data quality used to perform the risk screening assessment at SWMU 228A.

Because of the location, history of the site, and future land use (DOE et al. September 1995), there is low uncertainty in the land-use scenario and the potentially affected populations that were considered in making the risk assessment analysis. Because the COCs were found in surface soils and because of the location and physical characteristics of the site, there is little uncertainty in the exposure pathways relevant to the analysis.

An RME approach was used to calculate the risk assessment values. This means that the parameter values in the calculations were conservative and that calculated intakes were probably overestimates. Maximum measured values of COC concentrations were used to provide conservative results.

Table 6 shows the uncertainties (confidence) in nonradiological toxicological parameter values. There is a mixture of estimated values and values from the IRIS (EPA 1998a), the HEAST (EPA 1997a), and EPA Region 9 (EPA 1996b) electronic databases. Where values were not provided, information was not available from the HEAST (EPA 1997a), the IRIS (EPA 1998a), or the EPA regions (EPA 1996, 1997c). Because of the conservative nature of the RME approach, uncertainties in toxicological values were not expected to change the conclusion from the risk assessment analysis.

The calculated HI for the nonradiological COCs was within the human health acceptable range for the industrial land-use scenario compared to established numerical guidance. Although the excess cancer risk was above proposed guidelines, the excess cancer risk was conservatively estimated by using maximum concentrations of the detected COCs. Because the site was adequately characterized, average concentrations would be more representative of actual site conditions. If the 95th upper confidence limits of the means for benzo(a) pyrene (0.13 mg/kg), benzo(b) fluoranthene (0.18 mg/kg), and benzo(g,h,i) perylene (0.11 mg/kg) are used in place

of maximum concentrations, the excess cancer risk is calculated to be $8\text{E-}7$, which is within proposed guidelines considering an industrial land-use scenario.

For radiological COCs, the conclusion of the risk assessment was that potential effects on human health for both industrial and residential land-use scenarios were within guidelines and were a small fraction of the estimated 360 mrem/yr received by the average U.S. population (NCRP 1987).

The overall uncertainty in all of the steps in the risk assessment process is considered not significant with respect to the conclusion reached.

VI.9 Summary

This risk assessment identified COCs consisting of some organic, inorganic and radiological compounds at SWMU 228A. Because of the location of the site, the designated industrial land-use scenario, and the nature of contamination, potential exposure pathways identified for this site included soil ingestion and dust and volatile inhalation for chemical constituents and soil ingestion, dust inhalation, and direct gamma exposure for radionuclides. Plant uptake was included as an exposure pathway for the residential land-use scenario.

Using conservative assumptions and employing an RME approach to risk assessment, calculations for nonradiological COCs show that for the industrial land-use scenario the HI (0.03) was significantly less than the accepted numerical guidance from the EPA. Excess cancer risk ($2\text{E-}6$) was above the acceptable risk value provided by the NMED for an industrial land use scenario (NMED March 1998). The incremental HI was 0.03, and the incremental cancer risk was $1.52\text{E-}6$ for the industrial land-use scenario. Total and incremental HI risk calculations indicated insignificant risk to human health for an industrial land-use scenario.

Although the excess cancer risk was above proposed guidelines, the excess cancer risk was conservatively estimated by using maximum concentrations of the detected COCs. Because the site was adequately characterized, average concentrations are considered to be more representative of actual site conditions. If the 95th upper confidence limits of the means for benzo(a) pyrene (0.13 mg/kg), benzo(b) fluoranthene (0.18 mg/kg), and benzo(g,h,i) perylene (0.11 mg/kg) are used in place of maximum concentrations, the excess cancer risk is calculated to be $8\text{E-}7$, which is within proposed guidelines considering an industrial land-use scenario.

Incremental TEDE and corresponding estimated cancer risk from radiological COCs were much less than EPA guidance values. The estimated TEDE was $7.0\text{E-}1$ mrem/yr for the industrial land-use scenario, relative to 15 mrem/yr in EPA guidance (EPA 1997b). The corresponding incremental estimated cancer risk value was $7.8\text{E-}6$ for the industrial land-use scenario. Furthermore, the incremental TEDE for the residential land-use scenario that results from a complete loss of institutional control was only $2.7\text{E+}0$ mrem/yr with an associated risk of $2.5\text{E-}5$. The guideline for this scenario is 75 mrem/yr (SNL/NM February 1998). Therefore, SWMU 228A is eligible for unrestricted radiological release.

Uncertainties associated with the calculations are considered to be small relative to the conservatism of risk assessment analysis. It is, therefore, concluded that this site does not have potential to affect human health under an industrial land-use scenario.

VII. Ecological Risk Screening Assessment

VII.1 Introduction

This section addresses the ecological risks associated with exposure to COPECs in soils at SWMU 228A. A component of the NMED Risk-Based Decision Tree is to conduct an ecological screening assessment that corresponds with that presented in EPA's Ecological Risk Assessment Guidance for Superfund (EPA 1997d). The current methodology is tiered and contains an initial scoping assessment followed by a more detailed screening assessment. Initial components of NMED's decision tree (a discussion of DQOs, a data assessment, and evaluations of bioaccumulation and fate-and-transport potential) (NMED March 1998) are addressed in Sections II through V. Following the completion of the scoping assessment, a determination is made as to whether a more detailed examination of potential ecological risk is necessary. If deemed necessary, the scoping assessment proceeds to a screening assessment, whereby a more quantitative estimate of ecological risk is conducted. Although this assessment incorporates conservatism in the estimation of ecological risks, ecological relevance and professional judgment are also used as recommended by the EPA (1998b) to ensure that predicted exposures of selected ecological receptors reflect those reasonably expected to occur at the site.

VII.2 Scoping Assessment

The scoping assessment focuses primarily on the likelihood that biota at/or adjacent to the site will be exposed to constituents associated with site activities. Included in this section are an evaluation of existing data and a comparison of maximum detected concentrations to background concentrations, examination of bioaccumulation potential, and fate and transport potential. A scoping risk management decision will involve a summary of the scoping results and a determination as to whether further examination of potential ecological impacts is necessary.

VII.2.1 Data Assessment

As indicated in Section IV (Tables 3 and 4), inorganic constituents in soil within the 0- to 5-foot depth interval that exceeded background concentrations were:

- Barium
- Cadmium
- Lead
- U-233/234
- U-235
- U-238.

Mercury, selenium, and silver do not have quantified background screening levels, thus it was unknown if these COCs exceeded background. Therefore, these COCs were carried forward in the risk assessment process.

Several organic analytes were detected in soil which included:

- Benzene
- Methylene chloride
- Acenaphthene
- Anthracene
- Benzo(a)anthracene
- Benzo(a)pyrene
- Benzo(b)fluoranthene
- Benzo(g,h,i)perylene
- Benzo(k)fluoranthene
- Chrysene
- Di-n-butyl phthalate
- Bis(2-ethylhexyl)phthalate
- Fluoranthene
- Fluorene
- Indeno(1,2,3-cd)pyrene
- Phenanthrene
- Pyrene.

VII.2.2 Bioaccumulation

Among the COPECs listed in Section VII.2.1, the following were considered to have bioaccumulation potential in aquatic environments (Section IV, Tables 3 and 4):

- Barium
- Cadmium
- Lead
- Mercury
- Selenium
- Cs-137
- U-233/234
- U-235
- U-238
- Acenaphthene
- Anthracene
- Benzo(a)anthracene
- Benzo(a)pyrene
- Benzo(b)fluoranthene
- Benzo(g,h,i)perylene
- Benzo(k)fluoranthene
- Chrysene
- Di-n-butyl phthalate
- Bis(2-ethylhexyl)phthalate
- Fluoranthene
- Fluorene
- Indeno(1,2,3-cd)pyrene

- Phenanthrene
- Pyrene.

It should be noted, however, that as directed by the NMED (NMED March 1998), bioaccumulation for inorganics was assessed exclusively based upon maximum reported bioconcentration factors (BCF) for aquatic species. Because only aquatic BCFs are used to evaluate the bioaccumulation potential for metals, bioaccumulation in terrestrial species is likely to be overpredicted.

VII.2.3 Fate and Transport Potential

The potential for the COPECs to move from the source of contamination to other media or biota is discussed in Section V. As noted in Table 5 (Section V), surface-water runoff is expected to be low as transport mechanisms for COPECs at this site. Migration to groundwater is not anticipated. Both food chain uptake and degradation/transformation are of low significance.

VII.2.4 Scoping Risk Management Decision

Based upon information gathered through the scoping assessment, it was concluded that complete ecological pathways may be associated with this SWMU and that COPECs also exist at the site. As a consequence, a screening assessment was deemed necessary to predict the potential level of ecological risk associated with the site.

VII.3 Screening Assessment

As concluded in Section VII.2.4, complete ecological pathways and COPECs are associated with this SWMU. The screening assessment performed for the site involved a quantitative estimate of current ecological risks using exposure models in association with exposure parameters and toxicity information obtained from the literature. The estimation of potential ecological risks was conservative to ensure that ecological risks were not underpredicted.

Components within the screening assessment included:

- Problem Formulation—sets the stage for the evaluation of potential exposure and risk.
- Exposure Estimation—provides a quantitative estimate of potential exposure.
- Ecological Effects Evaluation—presents benchmarks used to gauge the toxicity of COPECs to specific receptors.
- Risk Characterization—characterizes the ecological risk associated with exposure of the receptors to environmental media at the site.
- Uncertainty Assessment—discusses uncertainties associated with the estimation of exposure and risk.

- Risk Interpretation—evaluates ecological risk in terms of HQs and ecological significance.
- Screening Assessment Scientific/Management Decision Point—presents the decision to risk managers based upon the results of the screening assessment.

VII.3.1 Problem Formulation

Problem formulation is the initial stage of the screening assessment that provides the introduction to the risk evaluation process. Components that are addressed in this section include a discussion of ecological pathways and the ecological setting, identification of COPECs, and selection of ecological receptors. The conceptual model, ecological food webs, and ecological endpoints (other components commonly addressed in a screening assessment) are presented in the "Predictive Ecological Risk Assessment Methodology, Environmental Restoration Program, Sandia National Laboratories/New Mexico" (IT July 1998) and are not duplicated here.

VII.3.1.1 *Ecological Pathways and Setting*

SWMU 228A is approximately 1.6 acres in size. The site is located in grassland habitat; however, much of the habitat at this site was disturbed during 1950s test operations and 1998 to 1999 VCM activities. Natural vegetation, including grasses, forbs, and shrubs, is partially restored through natural succession and revegetation work. The aridity of the site is exacerbated by its southern exposure. The site is open to use by wildlife, but the disturbed habitat conditions and lack of water at the site limit the quality of the habitat conditions for wildlife. Biological and sensitive species surveys were conducted in 1994 at both the centrifuge site (SWMU 50) and SWMU 228 (IT February 1995) with no sensitive species being found. No sensitive species are expected to occur at this site because of the habitat disturbance.

Complete ecological pathways may exist at this site through the exposure of plants and wildlife to COPECs in surface and subsurface soil. Direct uptake of COPECs from soil was assumed to be the major route of exposure for plants, with exposure of plants to wind-blown soil assumed to be minor. Exposure modeling for the wildlife receptors was limited to the food and soil ingestion pathways and exposure to external radiation. Because of the lack of surface water at this site, exposure to COPECs through the ingestion of surface water was considered insignificant. Inhalation and dermal contact were also considered insignificant pathways with respect to ingestion (Sample and Suter 1994). Groundwater is not expected to be affected by COPECs at this site.

VII.3.1.2 *COPECs*

The analytical results from soil samples collected at SWMU 228A are summarized in Tables 3 and 4 (Section IV). All soil samples were within the potential range of contact with ecological receptors (0 to 5 feet bgs), and therefore, all samples were used in the evaluation of COPECs. Both radiological and nonradiological analytes were evaluated as COPECs. The nonradiological COPECs included both inorganic and organic analytes. Inorganic analytes and radionuclides were screened against background concentrations, and those that exceeded the

approved SNL/NM background screening levels (Dinwiddie September 1997) for the area and those for which a definitive screening level had not been determined were considered to be COPECs. All organic analytes detected were considered to be COPECs. Nonradiological inorganics that are essential nutrients such as iron, magnesium, calcium, potassium, and sodium were not included in this risk assessment per the EPA (1989). In order to provide conservatism in this ecological risk assessment, the assessment was based upon the maximum soil concentrations of the COPECs measured at this site.

VII.3.1.3 *Ecological Receptors*

As described in detail in IT (July 1998), a nonspecific perennial plant was selected as the receptor to represent plant species at the site. Vascular plants are the principal primary producers at the site and are key to the diversity and productivity of the wildlife community associated with the site. The deer mouse (*Peromyscus maniculatus*) and the burrowing owl (*Speotyto cunicularia*) were used to represent wildlife use. Because of its opportunistic food habits, the deer mouse was used to represent a mammalian herbivore, omnivore, and insectivore. The burrowing owl was selected as the top predator. The burrowing owl is present at SNL/NM and is designated a species of management concern by the U.S. Fish and Wildlife Service in Region 2, which includes the state of New Mexico (USFWS September 1995).

VII.3.2 *Exposure Estimation*

For nonradiological COPECs, direct uptake from the soil was considered the only significant route of exposure for terrestrial plants. Exposure modeling for the wildlife receptors was limited to food and soil ingestion pathways. Inhalation and dermal contact were considered insignificant pathways with respect to ingestion (Sample and Suter 1994). Drinking water was also considered an insignificant pathway because of the lack of surface water at this site. The deer mouse was modeled under three dietary regimes: as an herbivore (100 percent of its diet as plant material), as an omnivore (50 percent of its diet as plants and 50 percent as soil invertebrates), and an insectivore (100 percent of its diet as soil invertebrates). The burrowing owl was modeled as a strict predator on small mammals (100 percent of its diet as deer mice). Because the exposure in the burrowing owl from a diet consisting of equal parts of herbivorous, omnivorous, and insectivorous mice is equal to the exposure from a diet consisting of only omnivorous mice, the diet of the burrowing owl was modeled with intake of omnivorous mice only. Both species were modeled with soil ingestion comprising 2 percent of the total dietary intake. Table 10 presents the species-specific factors used in modeling exposures in the wildlife receptors. Justification for use of the factors presented in this table is described in the ecological risk assessment methodology document (IT July 1998).

Although home range is also included in this table, exposures for this risk assessment were modeled using an area use factor of one, implying that all food items and soil ingested are from the site being investigated. The maximum measured COPEC concentrations from surface soil samples were used to provide a conservative estimate of potential exposures and risks to plants and wildlife at this site.

For radiological dose rate calculations, the deer mouse was modeled as an herbivore (100 percent of its diet as plants), and the burrowing owl was modeled as a strict predator on small mammals (100 percent of its diet as deer mice). Both were modeled with soil ingestion

Table 10
Exposure Factors for Ecological Receptors at SWMU 228A

Receptor Species	Class/Order	Trophic Level	Body Weight (kg) ^a	Food Intake Rate (kg/day) ^b	Dietary Composition ^c	Home Range (acres)
Deer mouse (<i>Peromyscus maniculatus</i>)	Mammalia/ Rodentia	Herbivore	2.39E-2 ^d	3.72E-3	Plants: 100% (+ soil at 2% of intake)	2.7E-1 ^e
Deer mouse (<i>Peromyscus maniculatus</i>)	Mammalia/ Rodentia	Omnivore	2.39E-2 ^d	3.72E-3	Plants: 50% Invertebrates: 50% (+ soil at 2% of intake)	2.7E-1 ^e
Deer mouse (<i>Peromyscus maniculatus</i>)	Mammalia/ Rodentia	Insectivore	2.39E-2 ^d	3.72E-3	Invertebrates: 100% (+ soil at 2% of intake)	2.7E-1 ^e
Burrowing owl (<i>Speotyto cunicularia</i>)	Aves/ Strigiformes	Carnivore	1.55E-1 ^f	1.73E-2	Rodents: 100% (+ soil at 2% of intake)	3.5E+1 ^g

^aBody weights are in kilograms wet weight.

^bFood intake rates are estimated from the allometric equations presented in Nagy (1987). Units are kilograms dry weight per day.

^cDietary compositions are generalized for modeling purposes. Default soil intake value of 2% of food intake.

^dFrom Silva and Downing (1995).

^eEPA (1993), based upon the average home range measured in semiarid shrubland in Idaho.

^fFrom Dunning (1993).

^gFrom Haug et al. (1993).

EPA = U.S. Environmental Protection Agency.

kg = Kilogram(s).

kg/day = Kilogram(s) per day.

SWMU = Solid Waste Management Unit.

comprising 2 percent of the total dietary intake. Receptors are exposed to radiation both internally and externally from uranium-233/234, uranium-235, and uranium-238. Internal and external dose rates to the deer mouse and the burrowing owl are approximated using modified dose rate models from the *Hanford Site Risk Assessment Methodology* (DOE 1995) as presented in the ecological risk assessment methodology document for the SNL/NM ER Program (IT July 1998). Radionuclide-dependent data for the dose-rate calculations were obtained from Baker and Soldat (1992). The external dose-rate model examines the total-body dose rate to a receptor residing in soil exposed to radionuclides. The soil surrounding the receptor is assumed to be an infinite medium uniformly contaminated with gamma-emitting radionuclides. The external dose-rate model is the same for both the deer mouse and the burrowing owl. The internal total-body dose-rate model assumes that a fraction of the radionuclide concentration ingested by a receptor is absorbed by the body and concentrated at the center of a spherical body shape. This provides a conservative estimate for absorbed dose. This concentrated radiation source at the center of the body of the receptor is assumed to be a point source. Radiation emitted from this point source is absorbed by the body tissues to contribute to the absorbed dose. Alpha and beta emitters are assumed to transfer 100 percent of their energy to the receptor as they pass through tissues. Gamma-emitting radionuclides only transfer a fraction of their energy to the tissues because gamma rays interact less with matter than do beta or alpha emitters. The external and internal dose rate results are summed to calculate a total dose rate from exposure to radionuclides in soil.

Table 11 presents the transfer factors used in modeling the concentrations of COPECs through the food chain. Table 12 presents maximum concentrations in soil and derived concentrations in tissues of the various food chain elements that are used to model dietary exposures for each of the wildlife receptors.

VII.3.3 Ecological Effects Evaluation

Benchmark toxicity values for the plant and wildlife receptors are presented in Table 13. For plants, the benchmark soil concentrations are based upon the lowest-observed-adverse-effect level (LOAEL). For wildlife, the toxicity benchmarks are based upon the no-observed-adverse-effect level (NOAEL) for chronic oral exposure in a taxonomically similar test species. Insufficient toxicity information was found to estimate the LOAELs or NOAELs for some COPECs for terrestrial plant life and wildlife receptors, respectively.

The benchmark used for exposure of terrestrial receptors to radiation was 0.1 rad/day. This value has been recommended by the International Atomic Energy Agency (IAEA 1992) for the protection of terrestrial populations. Because plants and insects are less sensitive to radiation than vertebrates (Whicker and Schultz 1982), the dose of 0.1 rad/day should also offer sufficient protection to other components within the terrestrial habitat of SWMU 228A.

VII.3.4 Risk Characterization

Maximum concentrations in soil and estimated dietary exposures were compared to plant and wildlife benchmark values, respectively. Results of these comparisons are presented in Table 14. HQs are used to quantify the comparison with benchmarks for plants and wildlife exposure.

Table 11
Transfer Factors Used in Exposure Models for
Constituents of Potential Ecological Concern at SWMU 228A

Constituent of Potential Ecological Concern	Soil-to-Plant Transfer Factor	Soil-to-Invertebrate Transfer Factor	Food-to-Muscle Transfer Factor
Inorganic			
Barium	1.5E-1 ^a	1.0E+0 ^b	2.0E-4 ^c
Cadmium	5.5E-1 ^a	6.0E-1 ^d	5.5E-4 ^a
Lead	9.0E-2 ^c	4.0E-2 ^d	8.0E-4 ^c
Mercury	1.0E+0 ^c	1.0E+0 ^b	2.5E-1 ^a
Selenium	5.0E-1 ^c	1.0E+0 ^b	1.0E-1 ^c
Silver	1.0E+0 ^c	2.5E-1 ^d	5.0E-3 ^c
Uranium	1.0E-2 ^c	1.0E+0 ^b	1.0E-2 ^a
Organic^e			
Benzene	2.3E+0	1.7E+1	2.9E-6
Methylene chloride	7.3E+0	1.5E+1	3.6E-7
Acenaphthene	2.1E-1	2.1E+1	2.1E-4
Anthracene	1.0E-1	2.2E+1	7.3E-4
Benzo(a)anthracene	2.2E-2	2.5E+1	1.2E-2
Benzo(a)pyrene	1.1E-2	2.7E+1	3.8E-2
Benzo(b)fluoranthene	6.2E-3	2.8E+1	1.1E-1
Benzo(g,h,i)perylene	2.6E-3	3.0E+1	5.4E-1
Benzo(k)fluoranthene	4.3E-3	2.9E+1	2.1E-1
Chrysene	1.5E-2	2.6E+1	2.3E-2
Di-n-butyl phthalate	8.4E-2	2.2E+1	1.1E-3
Bis(2-ethylhexyl)phthalate	2.3E-3	3.1E+1	6.4E-1
Fluoranthene	3.2E-2	2.4E+1	5.9E-3
Fluorene	1.5E-1	2.1E+1	3.8E-4
Indeno(1,2,3-cd)pyrene	1.5E-3	3.2E+1	1.5E+0
Phenanthrene	8.9E-2	2.2E+1	9.6E-4
Pyrene	3.3E-2	2.4E+1	5.8E-3

^aFrom Baes et al. (1984).

^bDefault value.

^cFrom NCRP (January 1989).

^dFrom Stafford et al. (1991).

^eSoil-to-plant and food-to-muscle transfer factors from equations developed in Travis and Arms (1988). Soil-to-invertebrate transfer factors from equations developed in Connell and Markwell (1990). All three equations based upon relationship of the transfer factor to the log K_{ow} value of compound.

K_{ow} = Octanol/water partition coefficient.

NCRP = National Council for Radiation Protection and Measurements.

SWMU = Solid Waste Management Unit.

Table 12
Media Concentrations^a for Constituents of
Potential Ecological Concern at SWMU 228A

Constituent of Potential Ecological Concern	Soil (maximum) ^a	Plant Foliage ^b	Soil Invertebrate ^b	Deer Mouse Tissues ^c
Inorganic				
Barium	2.2E+2	3.2E+1	2.2E+2	8.0E-2
Cadmium	1.8E+0	9.7E-1	1.1E+0	1.8E-3
Lead	4.1E+1	3.7E+0	1.6E+0	8.6E-3
Mercury	6.3E-2	6.3E-2	6.3E-2	5.0E-2
Selenium	9.2E-1	4.6E-1	9.2E-1	2.2E-1
Silver	4.4E-1	4.4E-1	1.1E-1	4.4E-3
Uranium	8.4E+1	8.4E-1	8.4E+1	1.4E+0
Organic				
Benzene	1.2E-3	2.7E-3	2.0E-2	1.1E-7
Methylene chloride	7.2E-3	5.3E-2	1.1E-1	9.1E-8
Acenaphthene	7.0E-2	1.5E-2	1.5E+0	4.7E-4
Anthracene	1.1E-1	1.1E-2	2.4E+0	2.8E-3
Benzo(a)anthracene	3.2E-1	7.1E-3	8.0E+0	1.4E-1
Benzo(a)pyrene	2.6E-1	3.0E-3	6.9E+0	4.1E-1
Benzo(b)fluoranthene	3.7E-1	2.3E-3	1.0E+1	1.8E+0
Benzo(g,h,i)perylene	2.5E-1	1.5E-3	7.0E+0	1.3E+0
Benzo(k)fluoranthene	2.8E-1	1.2E-3	8.1E+0	2.7E+0
Chrysene	3.7E-1	5.5E-3	9.6E+0	3.5E-1
Di-n-butyl phthalate	6.0E-2	5.0E-3	1.3E+0	2.2E-3
Bis(2-ethylhexyl)phthalate	1.1E-1	1.7E-4	3.5E+0	7.1E+0
Fluoranthene	6.3E-1	3.6E-2	1.5E+1	4.9E-2
Fluorene	5.0E-2	7.4E-3	1.1E+0	6.4E-4
Indeno(1,2,3-cd)pyrene	9.9E-2	6.0E-4	2.8E+0	5.0E-1
Phenanthrene	4.2E-1	3.7E-2	9.4E+0	1.4E-2
Pyrene	6.0E-1	2.0E-2	1.5E+1	1.3E-1

^aIn milligram(s) per kilogram. All are based upon dry weight of the media.

^bProduct of the soil concentration and the corresponding transfer factor.

^cBased upon the deer mouse with an omnivorous diet. Product of the average concentration in food times the food-to-muscle transfer factor times the wet weight-dry weight conversion factor of 3.125 (EPA 1993).
SWMU = Solid Waste Management Unit.

Table 13
Toxicity Benchmarks for Ecological Receptors at SWMU 228A

Constituent of Potential Ecological Concern	Plant Benchmark ^{a,b}	Mammalian NOAELs			Avian NOAELs		
		Mammalian Test Species ^{c,d}	Test Species NOAEL ^{d,e}	Deer Mouse NOAEL ^{e,f}	Avian Test Species ^d	Test Species NOAEL ^{d,g}	Burrowing Owl NOAEL ^{e,g}
Inorganic							
Barium	500	Rat ⁿ	10.5	5.1	Chicks	20.8	20.8
Cadmium	3	Rat ⁱ	1.0	1.9	Mallard	1.45	1.45
Lead	50	Rat	8.0	15.7	American kestrel	3.85	3.85
Mercury (inorganic)	0.3	Mouse	13.2	14.0	Japanese quail	0.45	0.45
Mercury (organic)	0.3	Rat	0.032	0.063	Mallard	0.0064	0.0064
Selenium	1	Rat	0.20	0.39	Screech owl	0.44	0.44
Silver	2	Rat	17.8 ^j	34.8	---	---	---
Uranium	5	Mouse ^k	3.07	3.19	Black duck	16.0	16.0
Organic							
Benzene	---	Mouse	26.4	27.9	---	---	---
Methylene chloride	---	Rat	5.85	11.4	---	---	---
Acenaphthene	18	Mouse ^m	17.5 ^m	18.5	---	---	---
Anthracene	18	Mouse ^m	100 ^m	106	---	---	---
Benzo(a)anthracene	18	Mouse ⁿ	1.0 ⁿ	1.06	---	---	---
Benzo(a)pyrene	18	Mouse	1.0	1.06	---	---	---
Benzo(b)fluoranthene	18	Mouse ⁿ	1.0 ⁿ	1.06	---	---	---
Benzo(g,h,i)perylene	18	Mouse ⁿ	1.0 ⁿ	1.06	---	---	---
Benzo(k)fluoranthene	18	Mouse ⁿ	1.0 ⁿ	1.06	---	---	---
Chrysene	18	Mouse ⁿ	1.0 ⁿ	1.06	---	---	---
Di-n-butyl phthalate	200	Mouse	550	582	Ringed dove	0.11	0.11
Bis(2-ethylhexyl)phthalate	---	Mouse	18.3	19.4	Ringed dove	1.1	1.1
Fluoranthene	18	Mouse ^m	12.5 ^m	13.2	---	---	---
Fluorene	18	Mouse ^m	12.5 ^m	13.2	---	---	---
Indeno(1,2,3-cd)pyrene	18	Mouse ⁿ	1.0 ⁿ	1.06	---	---	---
Phenanthrene	18	Mouse ⁿ	1.0 ⁿ	1.06	---	---	---
Pyrene	18	Mouse ^m	7.5 ^m	7.94	---	---	---

Refer to footnotes at end of table.

Table 13 (Concluded)
Toxicity Benchmarks for Ecological Receptors at SWMU 228A

^a In milligram(s) per kilogram soil.
^b From Efromson et al. (1997).
^c Body weights (in kilogram(s)) for the NOAEL conversion are as follows: lab mouse, 0.030; lab rat, 0.350 (except where noted).
^d From Sample et al. (1996), except where noted.
^e In milligram(s) per kilogram body weight per day.
^f Based upon NOAEL conversion methodology presented in Sample et al. (1996), using a deer mouse body weight of 0.0239 kilogram and a mammalian scaling factor of 0.25.
^g Based upon NOAEL conversion methodology presented in Sample et al. (1996). The avian scaling factor of 0.0 was used, making the NOAEL independent of body weight.
^h Body weight: 0.435 kilogram.
ⁱ Body weight: 0.303 kilogram.
^j Based upon a rat LOAEL of 89 mg/kg/d (EPA 1998a) and an uncertainty factor of 0.2.
^k Body weight: 0.028 kilogram.
^l Based upon toxicity information from Sims and Overcash (1983).
^m Based upon a toxicity information from EPA (1998a).
ⁿ Insufficient toxicity data available for this compound. The NOAEL for benzo(a)pyrene is used as a default.
EPA = U.S. Environmental Protection Agency.
LOAEL = Lowest-observed-adverse-effect level.
mg/kg/d = Milligram(s) per kilogram per day
NOAEL = No-observed-adverse-effect level
SWMU = Solid Waste Management Unit.
--- = Insufficient toxicity data.

Table 14
Hqs for Ecological Receptors at SWMU 228A

Constituent of Potential Ecological Concern	Plant HQ	Deer Mouse HQ (Herbivorous)	Deer Mouse HQ (Omnivorous)	Deer Mouse HQ (Insectivorous)	Burrowing Owl HQ
Inorganics					
Barium	4.3E-1	5.4E-1	1.9E+0	3.3E+0	2.4E-2
Cadmium	5.9E-1	8.3E-2	8.7E-2	9.1E-2	2.9E-3
Lead	8.1E-1	4.4E-2	3.4E-2	2.4E-2	2.4E-2
Mercury (inorganic)	2.1E-1	7.2E-4	7.2E-4	7.2E-4	1.3E-2
Mercury (organic)	2.1E-1	1.6E-1	1.6E-1	1.6E-1	9.0E-1
Selenium	9.2E-1	1.9E-1	2.8E-1	3.7E-1	6.1E-2
Silver	2.2E-1	2.0E-3	1.3E-3	5.3E-4	---
Uranium	1.7E+1	1.2E-1	2.2E+0	4.2E+0	2.1E-2
Organics					
Benzene	---	1.5E-5	6.4E-5	1.1E-4	---
Methylene chloride	---	7.2E-4	1.1E-3	1.5E-3	---
Acenaphthene	3.9E-3	1.4E-4	6.2E-3	1.2E-2	---
Anthracene	6.1E-3	2.0E-5	1.8E-3	3.6E-3	---
Benzo(a)anthracene	1.8E-2	2.0E-3	5.9E-1	1.2E+0	---
Benzo(a)pyrene	1.4E-2	1.2E-3	5.1E-1	1.0E+0	---
Benzo(b)fluoranthene	2.1E-2	1.4E-3	7.6E-1	1.5E+0	---
Benzo(g,h,i)perylene	1.4E-2	9.6E-4	5.2E-1	1.0E+0	---
Benzo(k)fluoranthene	1.6E-2	1.0E-3	6.0E-1	1.2E+0	---
Chrysene	2.1E-2	1.9E-3	7.1E-1	1.4E+0	---
Di-n-butyl phthalate	3.0E-4	1.7E-6	1.8E-4	3.6E-4	3.5E-3
Bis(2-ethylhexyl)phthalate	---	1.9E-5	1.4E-2	2.8E-2	7.2E-1
Fluoranthene	3.5E-2	5.7E-4	8.6E-2	1.7E-1	---
Fluorene	2.8E-3	9.9E-5	6.3E-3	1.3E-2	---
Indeno(1,2,3-cd)pyrene	5.5E-3	3.8E-4	2.1E-1	4.1E-1	---
Phenanthrene	2.3E-2	6.7E-3	6.9E-1	1.4E+0	---
Pyrene	3.3E-2	6.2E-4	1.4E-1	2.9E-1	---
HI ^a	2.0E+1	1.2E+0	9.5E+0	1.8E+1	1.8E+0

Refer to footnotes at end of table.

Table 14 (Concluded)
HQs for Ecological Receptors at SWMU 228A

Note: **Bold** text indicates HQ or HI exceeds unity.

^aThe HI is the sum of individual HQs using the value for organic mercury as a conservative estimate of the HI.

HI = Hazard index.

HQ = Hazard quotient.

SWMU = Solid Waste Management Unit.

--- = Insufficient toxicity data available for risk estimation purposes.

Uranium was the only COPEC that showed an HQ exceeding unity for plants. Both uranium and barium resulted in HQs greater than unity for the omnivorous and insectivorous deer mouse. Five of the polycyclic aromatic hydrocarbons (PAH) (benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, and phenanthrene), yielded HQs greater than 1.0 for the insectivorous diet of the deer mouse but not for either of the other two dietary regimes. No HQs were greater than 1.0 for either the herbivorous mouse or the burrowing owl. As directed by the NMED, HIs were calculated for each of the receptors (the HI is the sum of chemical-specific HQs for all pathways for a given receptor). All receptors had total HIs greater than unity, with a maximum HI of 20 for plants. The HI for PAHs also exceeded unity for the omnivorous and insectivorous deer mice.

Tables 15 and 16 summarize the internal and external dose-rate model results for U-235 and U-238. The total radiation dose rate to the deer mouse was predicted to be $2.1\text{E-}4$ rad/day. Total dose rate to the burrowing owl was predicted to be $1.1\text{E-}4$ rad/day. The internal dose rate from exposure to these radionuclides for both receptors is the primary contributor to the total dose rate. The dose rates for the deer mouse and the burrowing owl are considerably less than the benchmark of 0.1 rad/day.

VII.3.5 Uncertainty Assessment

Many uncertainties are associated with the characterization of ecological risks at SWMU 228A. These uncertainties result from assumptions used in calculating risk that may overestimate or underestimate true risk presented at a site. For this risk assessment, assumptions are made that are more likely to overestimate exposures and risk rather than to underestimate them. These conservative assumptions are used to provide more protection to the ecological resources potentially affected by the site. Conservatism incorporated into this risk assessment include the use of maximum measured analyte concentrations in soil to evaluate risk, the use of wildlife toxicity benchmarks based upon NOAEL values, the incorporation of strict herbivorous and strict insectivorous diets for predicting the extreme HQ values for the deer mouse, and the use of 1.0 as the area use factor for wildlife receptors regardless of seasonal use or home range size. Each of these uncertainties, which are consistent among each of the SWMU-specific ecological risk assessments, is discussed in greater detail in the uncertainty section of the ecological risk assessment methodology document for the SNL/NM ER Program (IT July 1998).

Uncertainties associated with the estimation of risk to ecological receptors following exposure to uranium-233/234, uranium-235, and uranium-238 are primarily related to those inherent in the radionuclide-specific data. Radionuclide-dependent data are measured values that have their associated errors, which are typically negligible. The dose-rate models used for these calculations are based upon conservative estimates on receptor shape, radiation absorption by body tissues, and intake parameters. The goal is to provide a realistic but conservative estimate of a receptor's exposure to radionuclides in soil, both internally and externally.

In estimating ecological risk, background concentrations are included as a component of maximum on-site concentrations. As shown in Table 17, conservatism in the modeling of exposure and risk for barium resulted in the prediction of risk to ecological receptors when exposed at the background concentration of 200 mg/kg. Background accounts for 93 percent

Table 15
Internal and External Dose Rates for
Deer Mice Exposed to Radionuclides at SWMU 228A

Radionuclide	Maximum Concentration (pCi/g)	Internal Dose (rad/day)	External Dose (rad/day)	Total Dose (rad/day)
U-233/234	1.64E+0	1.9E-5	1.9E-7	1.9E-7
U-235	8.0E-1	8.7E-6	1.3E-5	2.2E-5
U-238	1.1E+1	1.2E-4	2.3E-5	1.4E-4
Total		1.5E-4	3.6E-5	1.6E-4

pCi/g = Picocurie(s) per gram.

SWMU = Solid Waste Management Unit.

Table 16
Internal and External Dose Rates for
Burrowing Owls Exposed to Radionuclides at SWMU 228A

Radionuclide	Maximum Concentration (pCi/g)	Internal Dose (rad/day)	External Dose (rad/day)	Total Dose (rad/day)
U-233/234	1.64E+0	7.7E-6	1.9E-7	7.8E-6
U-235	8.0E-1	3.5E-6	1.3E-5	1.7E-5
U-238	1.1E+1	4.7E-5	2.3E-5	7.0E-5
Total		5.8E-5	3.6E-5	9.5E-5

pCi/g = Picocurie(s) per gram.

SWMU = Solid Waste Management Unit.

Table 17
HQs for Ecological Receptors Exposed to Background Concentrations for SWMU 228A

Constituent of Potential Ecological Concern	Plant HQ	Deer Mouse HQ (Herbivorous)	Deer Mouse HQ (Omnivorous)	Deer Mouse HQ (Insectivorous)	Burrowing Owl HQ
Inorganic					
Barium	4.0E-1	5.0E-1	1.8E+0	3.0E+0	2.2E-2
Cadmium	1.7E-1	2.4E-2	2.5E-2	2.6E-2	8.1E-4
Lead	2.2E-1	1.2E-2	9.5E-3	6.7E-3	6.6E-3
Mercury (inorganic)	1.7E-1	5.7E-4	5.7E-4	5.7E-4	1.0E-2
Mercury (organic)	1.7E-1	1.3E-1	1.3E-1	1.3E-1	7.1E-1
Selenium	5.0E-1	1.0E-1	1.5E-1	2.0E-1	3.3E-2
Silver	2.5E-1	2.3E-3	1.4E-3	6.0E-4	---
Uranium	5.5E-1	3.4E-3	5.9E-2	1.1E-1	5.8E-4
HI ^a	2.3E+0	7.7E-1	2.1E+0	3.5E+0	7.8E-1

Note: **Bold** text indicates HQ or HI exceeds unity.

^aThe HI is the sum of individual HQs using the value for organic mercury as a conservative estimate of the HI.

HI = Hazard index.

HQ = Hazard quotients.

SWMU = Solid Waste Management Unit.

--- = Insufficient toxicity data available for risk estimation purposes.

of the maximum measured barium concentrations at SWMU 228A, and only three of the 68 soil samples analyzed for inorganics showed barium concentrations exceeding the background screening value. Therefore, because of the uncertainties associated with exposure and toxicity, it is unlikely that barium (with exposure concentrations largely attributable to background) presents significant ecological risk at this site.

The assumption of an area use factor of 1.0 is a source of uncertainty for the burrowing owl. Because SWMU 228A is approximately 1.6 acres in size, an area use factor of approximately 0.046 would be justified for this receptor. Therefore, although no COPECs produced HQs greater than unity for this species, the assumption of an area use factor of 1.0 has resulted in the overestimation of the HQs by a factor of about 20, indicating that these HQs are highly conservative.

A significant source of uncertainty associated with the prediction of ecological risks at this site is the use of the maximum measured concentrations to evaluate risk. This results in a conservative exposure scenario that does not necessarily reflect actual site conditions. To assess the potential degree of overestimation caused by using the maximum measured soil concentrations in the exposure assessment, average soil concentrations (using the method detection limits for nondetects) were calculated for each COPEC that exhibited one or more HQ(s) greater than unity to determine whether the exceedence can be accounted for by the magnitude of the extreme measurement.

The average concentration of barium (at 125 mg/kg) was well below the background screening value (200 mg/kg). The average concentration of uranium (at 28.5 mg/kg) was 34 percent of the maximum value, which is sufficient to reduce the HQ for the omnivorous deer mouse to less than unity and HQs for plants and the insectivorous deer mouse to 5.8 and 1.4, respectively. It should be noted that this HQ for plants is based on a LOAEL from a toxicity study that used uranyl nitrate as a soil amendment (Efroymson et al. 1997), whereas the measured uranium concentrations in the soil samples from SWMU 228A are of total uranium and probably include a high proportion that is in a form much less available for plant uptake than that of the toxicity study. It should also be noted that the exposures to uranium for the omnivorous and insectivorous deer mice are based on the default soil-to-invertebrate transfer factor of 1.0. That the actual uptake of uranium by invertebrates is probably much less results in further reductions of the HQs for these receptors. For these reasons, the risks to plants and wildlife from exposures to uranium at this site are expected to be low.

The average concentrations for the five PAHs that showed HQs greater than 1.0 were 0.058 mg/kg for benzo(a)anthracene, 0.065 mg/kg for benzo(b)fluoranthene, 0.033 mg/kg for benzo(k)fluoranthene, 0.066 mg/kg for chrysene, and 0.051 mg/kg for phenanthrene. All of these average concentrations are sufficiently below the maximum concentrations to reduce the HQs to values less than 1.0. It should be noted that for all of these PAHs, compound-specific toxicity information could not be found, and therefore, the NOAELs were conservatively based upon the NOAEL for benzo(a)pyrene. It is likely that the toxicities of these compounds are actually less than that of benzo(a)pyrene.

Based upon this uncertainty analysis, ecological risks at SWMU 228A are expected to be low. HQs greater than unity are predicted; however, closer examination of the exposure assumptions reveals an overestimation of risk primarily attributed to treatment of exposure

concentration, conservative exposure modeling assumptions, and conservative toxicity benchmark values.

VII.3.6 Risk Interpretation

Ecological risks associated with SWMU 228A were estimated through a screening assessment that incorporated site-specific information when available. Overall, risks to ecological receptors are expected to be low because predicted risks associated with exposure to COPECs are based upon calculations using maximum detected values. The average barium concentration at the site was within the range of background concentrations. Predicted risks from exposure to uranium and to five PAHs were attributed to the use of maximum detected values. Additionally, conservative assumptions of the availability and uptake of uranium by plants and invertebrates probably resulted in estimated exposures that do not reflect actual site conditions. No COPECs were predicted to be hazardous to the burrowing owl or the herbivorous deer mouse. Based upon this final analysis, ecological risks associated with SWMU 228A are expected to be low.

VII.3.7 Screening Assessment Scientific/Management Decision Point

Once potential ecological risks associated with the site have been assessed, a decision is made as to whether the site should be recommended for NFA or whether additional data should be collected to assess actual ecological risk at the site more thoroughly. With respect to this site, ecological risks were predicted to be low. The scientific/management decision is to recommend this site for NFA.

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APPENDIX 1 EXPOSURE PATHWAY DISCUSSION FOR CHEMICAL AND RADIONUCLIDE CONTAMINATION

Introduction

Sandia National Laboratories (SNL/NM) proposes that a default set of exposure routes and associated default parameter values be developed for each future land-use designation being considered for SNL/NM Environmental Restoration (ER) project sites. This default set of exposure scenarios and parameter values would be invoked for risk assessments unless site-specific information suggested other parameter values. Because many SNL/NM solid waste management units (SWMU) have similar types of contamination and physical settings, SNL/NM believes that the risk assessment analyses at these sites can be similar. A default set of exposure scenarios and parameter values will facilitate the risk assessments and subsequent review.

The default exposure routes and parameter values suggested are those that SNL/NM views as resulting in a Reasonable Maximum Exposure (RME) value. Subject to comments and recommendations by the U.S. Environmental Protection Agency (EPA) Region VI and New Mexico Environment Department (NMED), SNL/NM proposes that these default exposure routes and parameter values be used in future risk assessments.

At SNL/NM, all SWMUs exist within the boundaries of the Kirtland Air Force Base (KAFB). Approximately 157 potential waste and release sites have been identified where hazardous, radiological, or mixed materials may have been released to the environment. Evaluation and characterization activities have occurred at all of these sites to varying degrees. Among other documents, the SNL/NM ER draft Environmental Assessment (DOE 1996) presents a summary of the hydrogeology of the sites, the biological resources present and proposed land-use scenarios for the SNL/NM SWMUs. At this time, all SNL/NM SWMUs have been tentatively designated for either industrial or recreational future land use. The NMED has also requested that risk calculations be performed based upon a residential land-use scenario. All three land-use scenarios will be addressed in this document.

The SNL/NM ER project has screened the potential exposure routes and identified default parameter values to be used for calculating potential intake and subsequent Hazard index (HI), excess cancer risk and dose values. The EPA (EPA 1989a) provides a summary of exposure routes that could potentially be of significance at a specific waste site. These potential exposure routes consist of:

- Ingestion of contaminated drinking water
- Ingestion of contaminated soil
- Ingestion of contaminated fish and shell fish
- Ingestion of contaminated fruits and vegetables
- Ingestion of contaminated meat, eggs, and dairy products
- Ingestion of contaminated surface water while swimming
- Dermal contact with chemicals in water
- Dermal contact with chemicals in soil
- Inhalation of airborne compounds (vapor phase or particulate)

- External exposure to penetrating radiation (immersion in contaminated air; immersion in contaminated water and exposure from ground surfaces with photon-emitting radionuclides).

Based upon the location of the SNL/NM SWMUs and the characteristics of the surface and subsurface at the sites, we have evaluated these potential exposure routes for different land-use scenarios to determine which should be considered in risk assessment analyses (the last exposure route is pertinent to radionuclides only). At SNL/NM SWMUs, there does not currently occur any consumption of fish, shell fish, fruits, vegetables, meat, eggs, or dairy products that originate on site. Additionally, no potential for swimming in surface water is present due to the high-desert environmental conditions. As documented in the RESRAD computer code manual (ANL 1993), risks resulting from immersion in contaminated air or water are not significant compared to risks from other radiation exposure routes.

For the industrial and recreational land-use scenarios, SNL/NM ER has, therefore, excluded the following four potential exposure routes from further risk assessment evaluations at any SNL/NM SWMU:

- Ingestion of contaminated fish and shell fish
- Ingestion of contaminated fruits and vegetables
- Ingestion of contaminated meat, eggs, and dairy products
- Ingestion of contaminated surface water while swimming.

That part of the exposure pathway for radionuclides related to immersion in contaminated air or water is also eliminated.

For the residential land-use scenario, we will include ingestion of contaminated fruits and vegetables because of the potential for residential gardening.

Based upon this evaluation, for future risk assessments, the exposure routes that will be considered are shown in Table 1. Dermal contact is included as a potential exposure pathway in all land-use scenarios. However, the potential for dermal exposure to inorganics is not considered significant and will not be included. In general, the dermal exposure pathway is generally considered to not be significant relative to water ingestion and soil ingestion pathways but will be considered for organic components. Because of the lack of toxicological parameter values for this pathway, the inclusion of this exposure pathway into risk assessment calculations may not be possible and may be part of the uncertainty analysis for a site where dermal contact is potentially applicable.

Equations and Default Parameter Values for Identified Exposure Routes

In general, SNL/NM expects that ingestion of compounds in drinking water and soil will be the more significant exposure routes for chemicals; external exposure to radiation may also be significant for radionuclides. All of the above routes will, however, be considered for their appropriate land-use scenarios. The general equations for calculating potential intakes via these routes are shown below. The equations are from the Risk Assessment Guidance for Superfund (RAGS): Volume 1 (EPA 1989a, 1991). These general equations also apply to calculating potential intakes for radionuclides. A more in-depth discussion of the equations

Table 1
Exposure Pathways Considered for Various Land-Use Scenarios

Industrial	Recreational	Residential
Ingestion of contaminated drinking water	Ingestion of contaminated drinking water	Ingestion of contaminated drinking water
Ingestion of contaminated soil	Ingestion of contaminated soil	Ingestion of contaminated soil
Inhalation of airborne compounds (vapor phase or particulate)	Inhalation of airborne compounds (vapor phase or particulate)	Inhalation of airborne compounds (vapor phase or particulate)
Dermal contact	Dermal contact	Dermal contact
External exposure to penetrating radiation from ground surfaces	External exposure to penetrating radiation from ground surfaces	Ingestion of fruits and vegetables
		External exposure to penetrating radiation from ground surfaces

used in performing radiological pathway analyses with the RESRAD code may be found in the RESRAD Manual (ANL 1993). Also shown are the default values SNL/NM ER suggests for use in RME risk assessment calculations for industrial, recreational, and residential scenarios, based upon EPA and other governmental agency guidance. The pathways and values for chemical contaminants are discussed first, followed by those for radionuclide contaminants. RESRAD input parameters that are left as the default values provided with the code are not discussed. Further information relating to these parameters may be found in the RESRAD Manual (ANL 1993).

Generic Equation for Calculation of Risk Parameter Values

The equation used to calculate the risk parameter values (i.e., hazard quotients/hazard index [HI], excess cancer risk, or radiation total effective dose equivalent [dose]) is similar for all exposure pathways and is given by:

$$\begin{aligned} \text{Risk (or Dose)} &= \text{Intake} \times \text{Toxicity Effect (either carcinogenic, noncarcinogenic, or radiological)} \\ &= C \times (CR \times EFD/BW/AT) \times \text{Toxicity Effect} \end{aligned} \quad (1)$$

where

C = contaminant concentration (site specific)
 CR = contact rate for the exposure pathway
 EFD = exposure frequency and duration
 BW = body weight of average exposure individual
 AT = time over which exposure is averaged.

The total risk/dose (either cancer risk or HI) is the sum of the risks/doses for all of the site-specific exposure pathways and contaminants.

The evaluation of the carcinogenic health hazard produces a quantitative estimate for excess cancer risk resulting from the constituents of concern (COC) present at the site. This estimate

is evaluated for determination of further action by comparison of the quantitative estimate with the potentially acceptable risk range of $1\text{E-}6$ for Class A and B carcinogens and $1\text{E-}5$ for Class C carcinogens. The evaluation of the noncarcinogenic health hazard produces a quantitative estimate (i.e., the HI) for the toxicity resulting from the COCs present at the site. This estimate is evaluated for determination of further action by comparison of this quantitative estimate with the EPA standard HI of unity (1). The evaluation of the health hazard due to radioactive compounds produces a quantitative estimate of doses resulting from the COCs present at the site.

The specific equations used for the individual exposure pathways can be found in RAGS (EPA 1989a) and the RESRAD Manual (ANL 1993). Table 2 shows the default parameter values suggested for used by SNL/NM at SWMUs, based upon the selected land-use scenario. References are given at the end of the table indicating the source for the chosen parameter values. The intention of SNL/NM is to use default values that are consistent with regulatory guidance and consistent with the RME approach. Therefore, the values chosen will, in general, provide a conservative estimate of the actual risk parameter. These parameter values are suggested for use for the various exposure pathways based upon the assumption that a particular site has no unusual characteristics that contradict the default assumptions. For sites for which the assumptions are not valid, the parameter values will be modified and documented.

Summary

SNL/NM proposes the described default exposure routes and parameter values for use in risk assessments at sites that have an industrial, recreational or residential future land-use scenario. There are no current residential land-use designations at SNL/NM ER sites, but this scenario has been requested to be considered by the NMED. For sites designated as industrial or recreational land use, SNL/NM will provide risk parameter values based upon a residential land-use scenario to indicate the effects of data uncertainty on risk value calculations or in order to potentially mitigate the need for institutional controls or restrictions on SNL/NM ER sites. The parameter values are based upon EPA guidance and supplemented by information from other government sources. The values are generally consistent with those proposed by Los Alamos National Laboratory, with a few minor variations. If these exposure routes and parameters are acceptable, SNL/NM will use them in risk assessments for all sites where the assumptions are consistent with site-specific conditions. All deviations will be documented.

Table 2
Default Parameter Values for Various Land-Use Scenarios

Parameter	Industrial	Recreational	Residential
General Exposure Parameters			
Exposure frequency (day/yr)	***	***	***
Exposure duration (yr)	25 ^{a,b}	30 ^{a,b}	30 ^{a,b}
Body weight (kg)	70 ^{a,b}	70 adult ^{a,b} 15 child	70 adult ^{a,b} 15 child
Averaging Time (days) for carcinogenic compounds (= 70 y x 365 day/yr) for noncarcinogenic compounds (= ED x 365 day/yr)	25550 ^a 9125	25550 ^a 10950	25550 ^a 10950
Soil Ingestion Pathway			
Ingestion rate	100 mg/day ^c	200 mg/day child 100 mg/day adult	200 mg/day child 100 mg/day adult
Inhalation Pathway			
Inhalation rate (m ³ /yr)	5000 ^{a,b}	260 ^d	7000 ^{a,b,d}
Volatilization factor (m ³ /kg)	chemical specific	chemical specific	chemical specific
Particulate emission factor (m ³ /kg)	1.32E9 ^a	1.32E9 ^a	1.32E9 ^a
Water Ingestion Pathway			
Ingestion rate (L/day)	2 ^{a,b}	2 ^{a,b}	2 ^{a,b}
Food Ingestion Pathway			
Ingestion rate (kg/yr)	NA	NA	138 ^{b,d}
Fraction ingested	NA	NA	0.25 ^{b,d}
Dermal Pathway			
Surface area in water (m ²)	2 ^{b,e}	2 ^{b,e}	2 ^{b,e}
Surface area in soil (m ²)	0.53 ^{b,e}	0.53 ^{b,e}	0.53 ^{b,e}
Permeability coefficient	chemical specific	chemical specific	chemical specific

***The exposure frequencies for the land-use scenarios are often integrated into the overall contact rate for specific exposure pathways. When not included, the exposure frequency for the industrial land-use scenario is 8 hr/day for 250 day/yr; for the recreational land use, a value of 2 hr/wk for 52 wk/yr is used (EPA 1989b); for a residential land use, all contact rates are given per day for 350 day/yr.

^aRAGS, Vol 1, Part B (EPA 1991).

^bExposure Factors Handbook (EPA 1989b)

^cEPA Region VI guidance.

^dFor radionuclides, RESRAD (ANL 1993) is used for human health risk calculations; default parameters are consistent with RESRAD guidance.

^eDermal Exposure Assessment (EPA 1992).

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